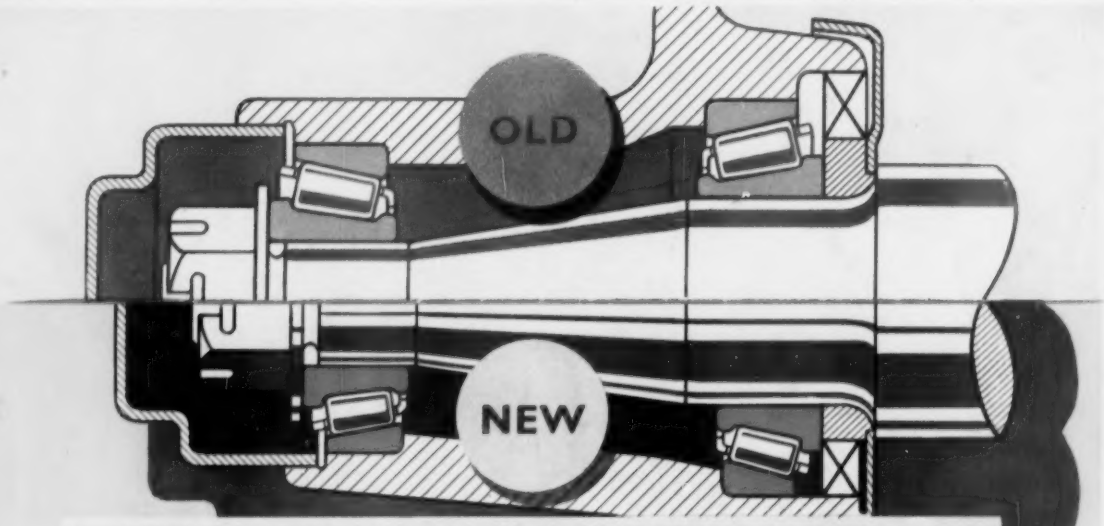
AUTOMOBILE ENGINEER

DESIGN · PRODUCTION · MATERIALS

Vol. 46 No. 2 **FEBRUARY 1956** PRICE: 3s. 6d.



ECONOMIES

The sectional drawing shows, actual size, the economy in size of our new front wheel bearings compared with previous types generally used. These bearings—of which particulars will be sent on request—fit the same stub axle and provide ample load capacity and great resistance to tilting, but are substantially smaller and lighter. As a result, the diameter and length of the hub may be reduced, and the diameter of the seal and hub-cap.

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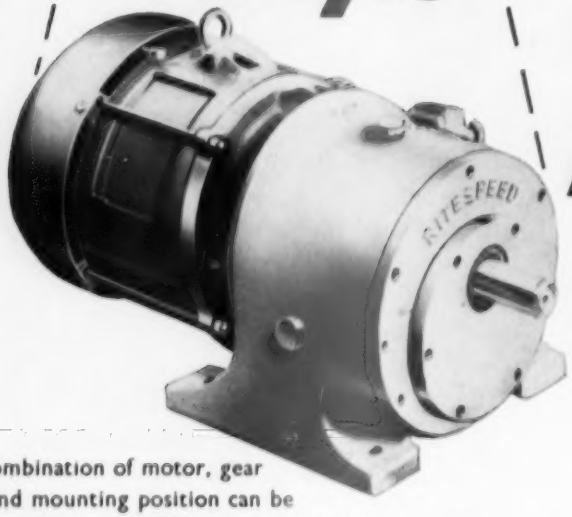

Any combination of motor, gear ratio and mounting position can be supplied. Units up to 20 H.P. are available from stock, larger sizes on quick delivery. Ratios up to 82-1.

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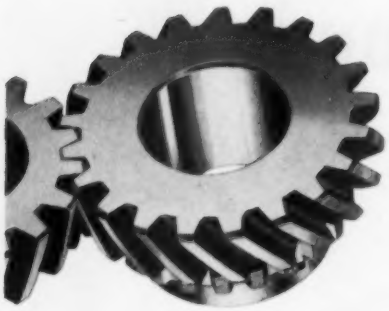
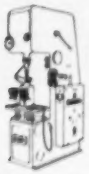
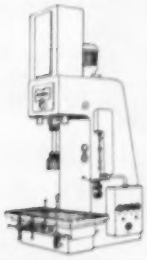


Nagel Horizontal Honing Machine. Capacity from ¼" to 2½" dia. bores.

Nagel Brake Drum Superfinishing Machine. Automatic work cycle with hydraulic clamping.



Nagel VM Type High Duty Machine especially suitable for hard-chromed components.



Nagel Long Stroke Honing Machine. Strokes from 24" to 48" with capacity from 1¼" to 20" dia. bores.

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Other features in this issue include:

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'Ship's Emergency Electricity Supply'—dealing with the Allen 350 kW gas-turbine set.

'A Versatile Small Gas Turbine'—uses of Nimonic Alloys in the Blackburn-Houchin generating set.

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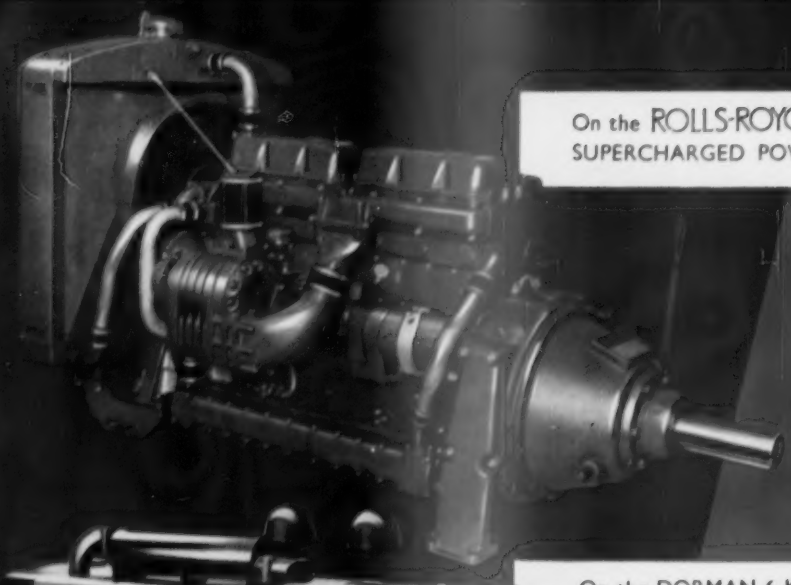
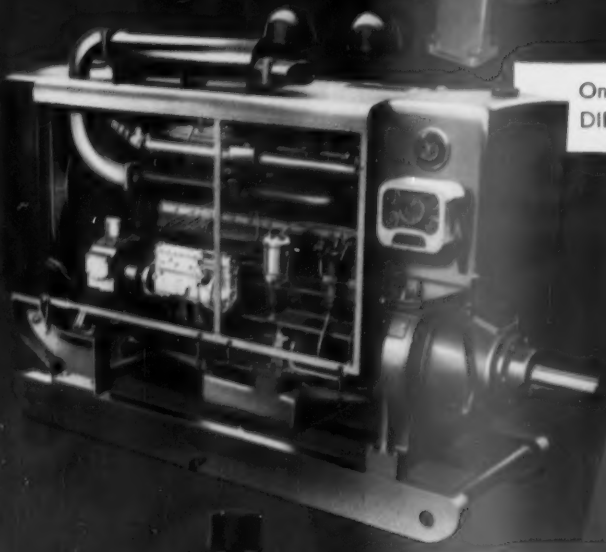
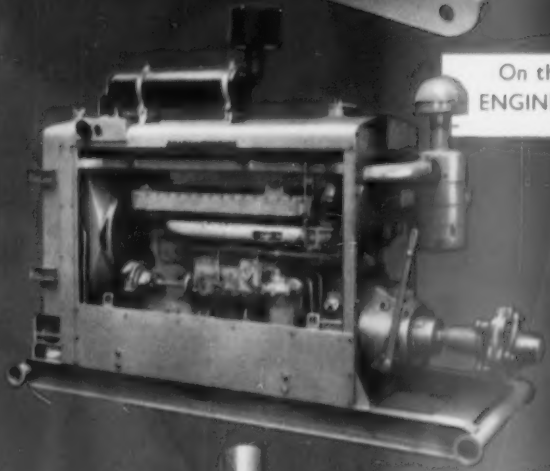


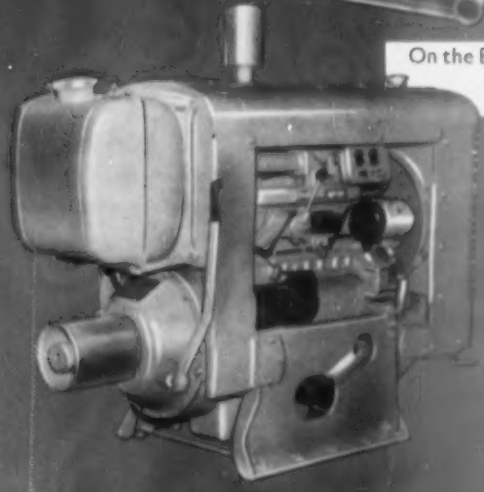
On the ROLLS-ROYCE C6 SFL
SUPERCHARGED POWER UNIT



On the DORMAN 6 KA
DIESEL POWER PACK



On the LEYLAND DIESEL
ENGINE FOR THE OILFIELDS



On the BOLINDER'S STATIONARY DIESEL
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Rockford over-centre clutches and power take-offs are being used by a great many of the leading manufacturers, some of whose units are shown here.

Rockford clutches are especially suitable for use in such units, because there is no running thrust in either the engaged or disengaged position. Further, the operating toggle mechanism is centrifugally balanced, and has a simple adjustment for wear.

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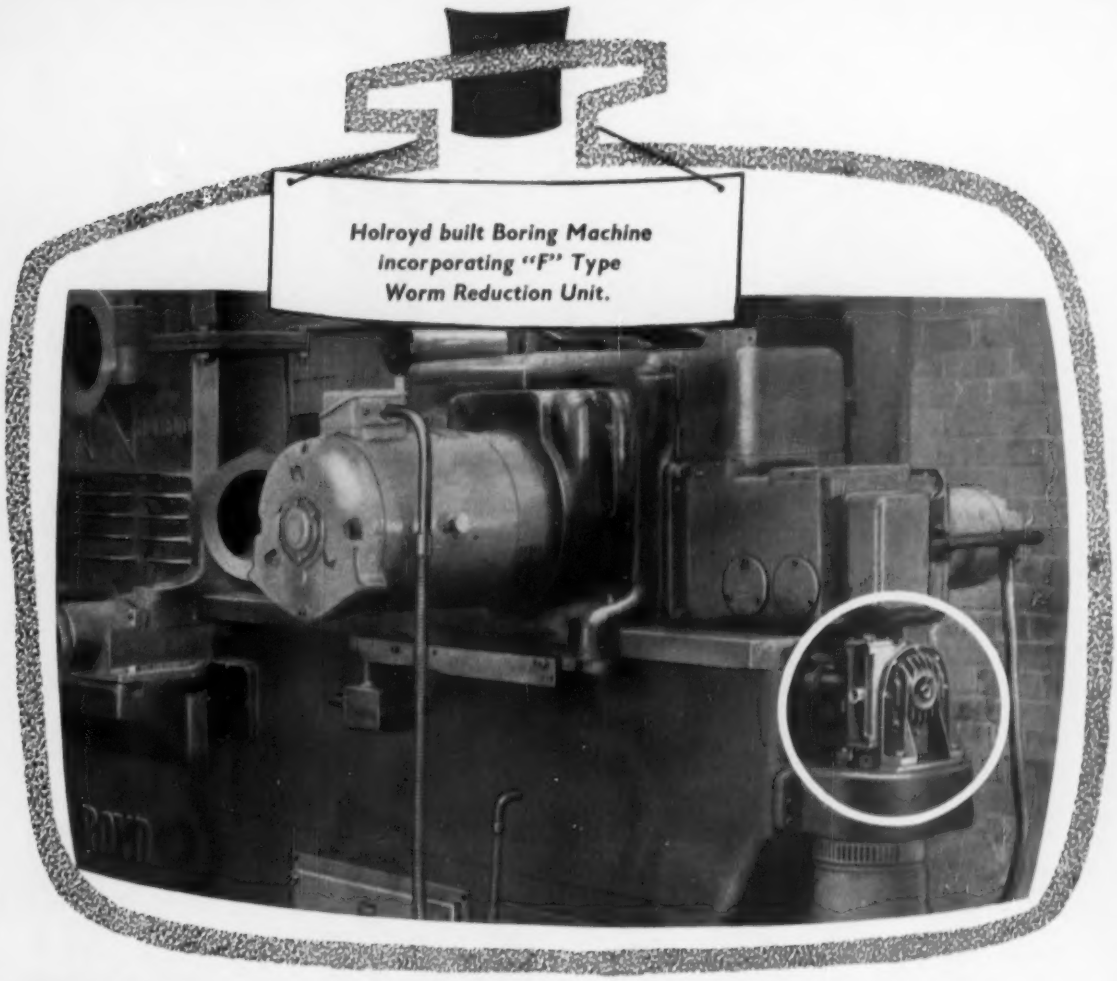

Holroyd built Boring Machine incorporating "F" Type Worm Reduction Unit.

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When we get a headache about a job we're doing we often take a spot of our own medicine and it puts us on top of the world in no time. A case in point is this Holroyd Boring Machine. We used one of our own "F" Type motorised Worm Reduction Units to drive the feed and quick return motions—and it worked like a dose of salts. A Holroyd Worm Unit might do *you* a power of good. It can be . . .

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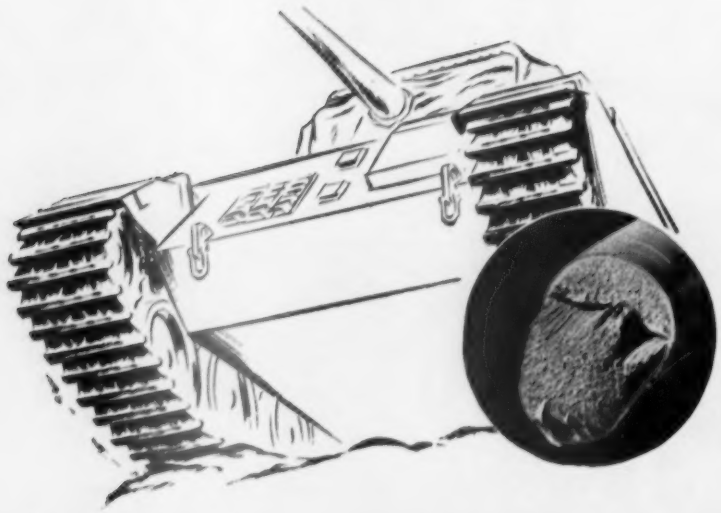

SURFACE HARDENING of tank track pins

Tank track pins are being surface hardened with a G.E.C. high frequency induction hardening machine at the Cardiff works of Curran Steels Ltd. The pins are hardened to a minimum of 54 Rockwell C and to depths varying from .025" to .050". Previously it was found difficult —and with one pin size impossible—to restrict the hardened surface to acceptable limits and all pins had subsequently to be straightened.

Write for details of G.E.C. high frequency heating.

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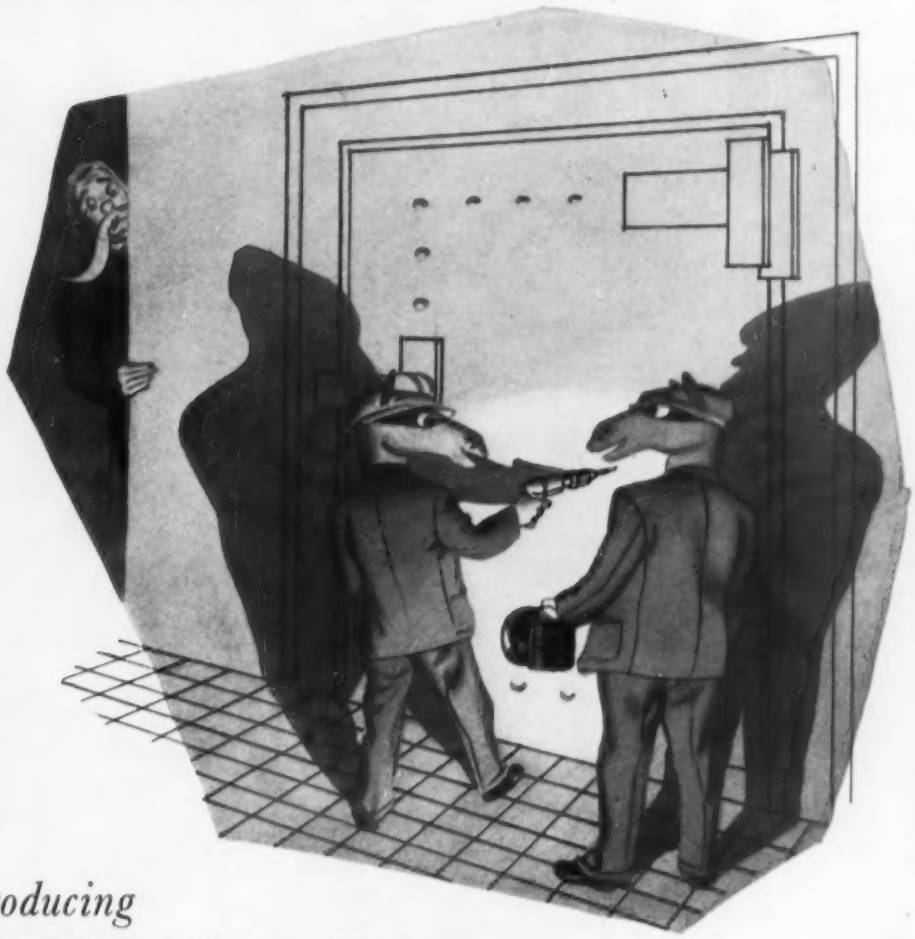

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'Raffles' Desoutter

People who make safes do so with the idea of frustrating burglars who want to bore their way in. Aircraft Designers appear to have much the same intention towards the long-suffering engineers who have to make and assemble their designs. Take Titanium for instance. (All right, *don't* take it! But if you have to drill holes in an Aircraft Factory you have no choice). Normal high speed power tools work themselves and their operators into a state of great heat, blunt edges and even blunter words. Enter 'Raffles' Desoutter, the Little Horse who works at speeds from 160 to 300 r.p.m. and will bore his way into the Bank of England. He is available in an increasing range of Desoutter Tools.

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CBG. 271

One 56 lb. and two 1 cwt. Birlec induction furnaces, for melting the nickel alloy used in the manufacture of the casting shown below—one of the side links of a Birlec heavy duty furnace conveyor belt. Photographs by courtesy of Samuel Osborn & Co., Ltd., Sheffield.

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For shell moulding or investment casting capacities of 25 lb. and over, Birlec high frequency induction furnaces provide high quality metal of accurate analysis and with exact temperature control. For smaller outputs the Birlec Detroit I.C. (investment casting) furnace is similarly suitable.

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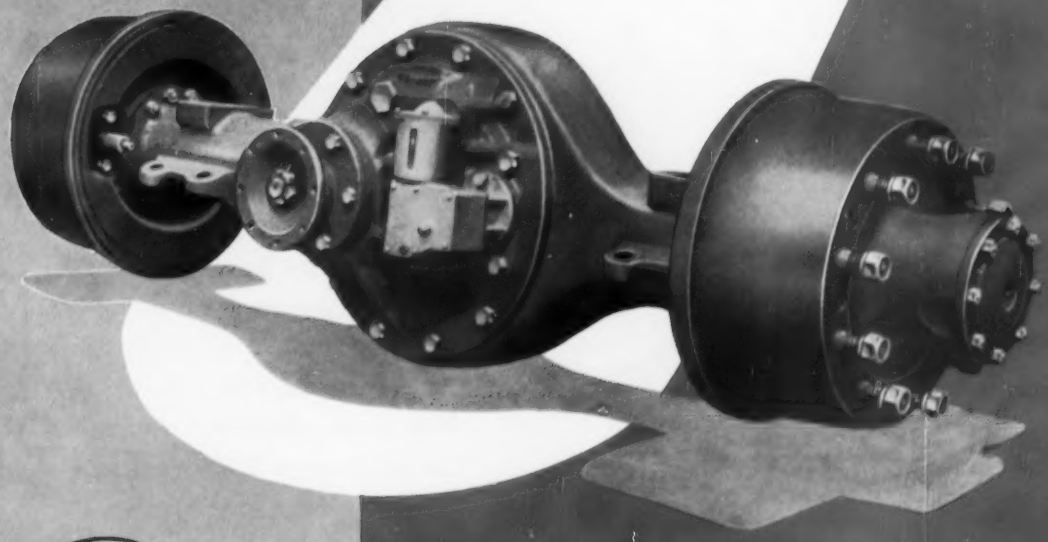

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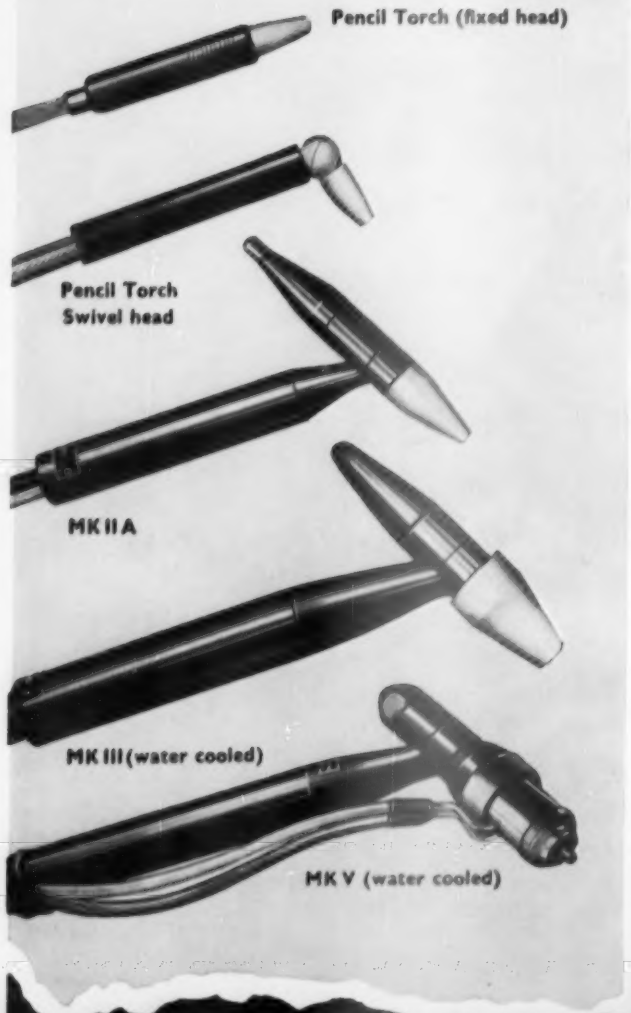

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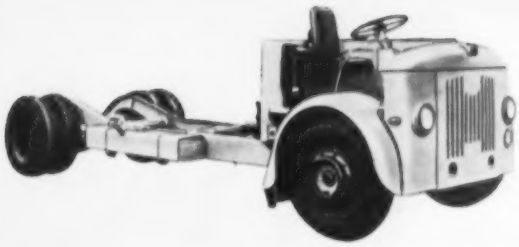

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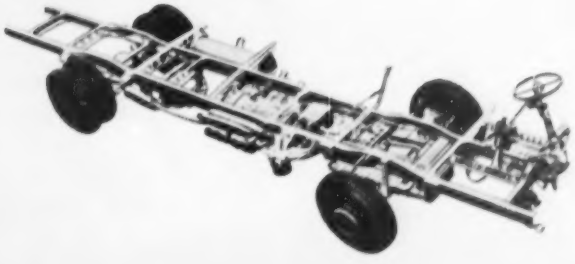

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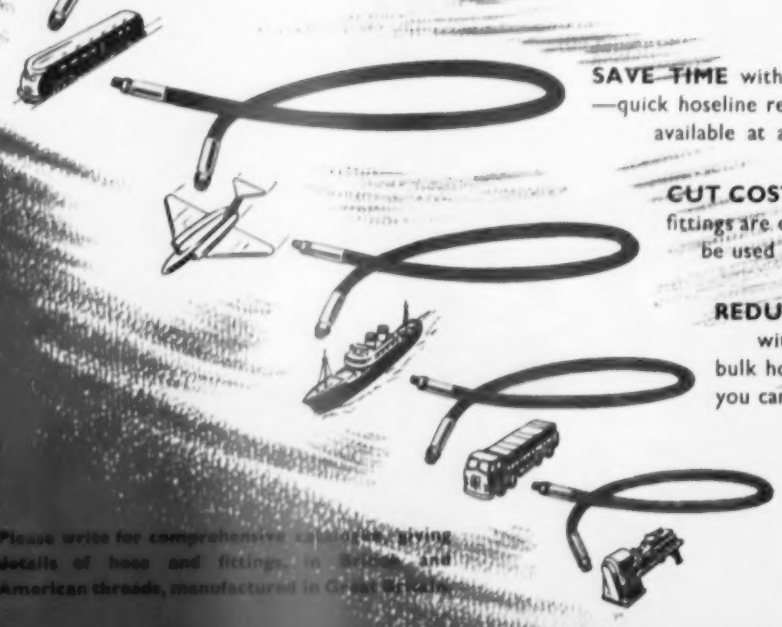

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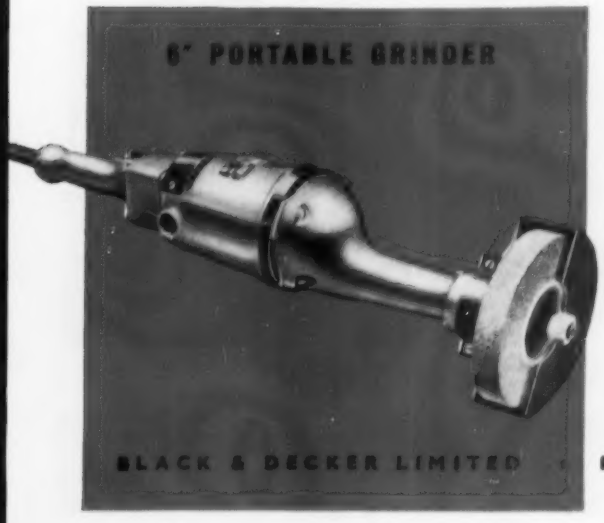

Redesigned to give 85% more power, the latest, lighter 6" Portable Grinder is ideal for sustained grinding, buffing and wire brushing jobs.

These two new powerful tools give greater output-faster than ever before

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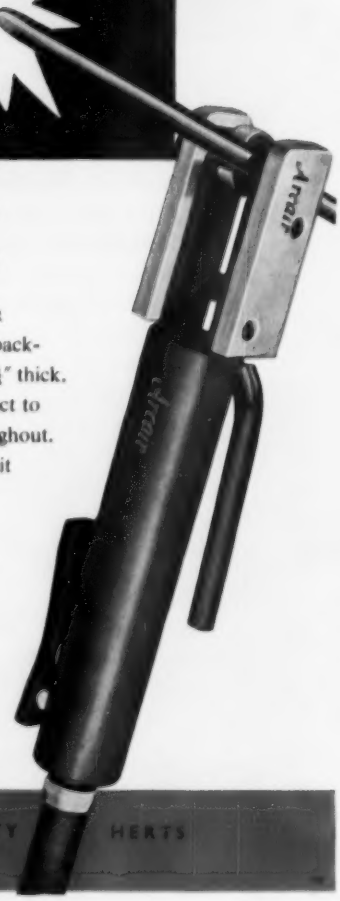

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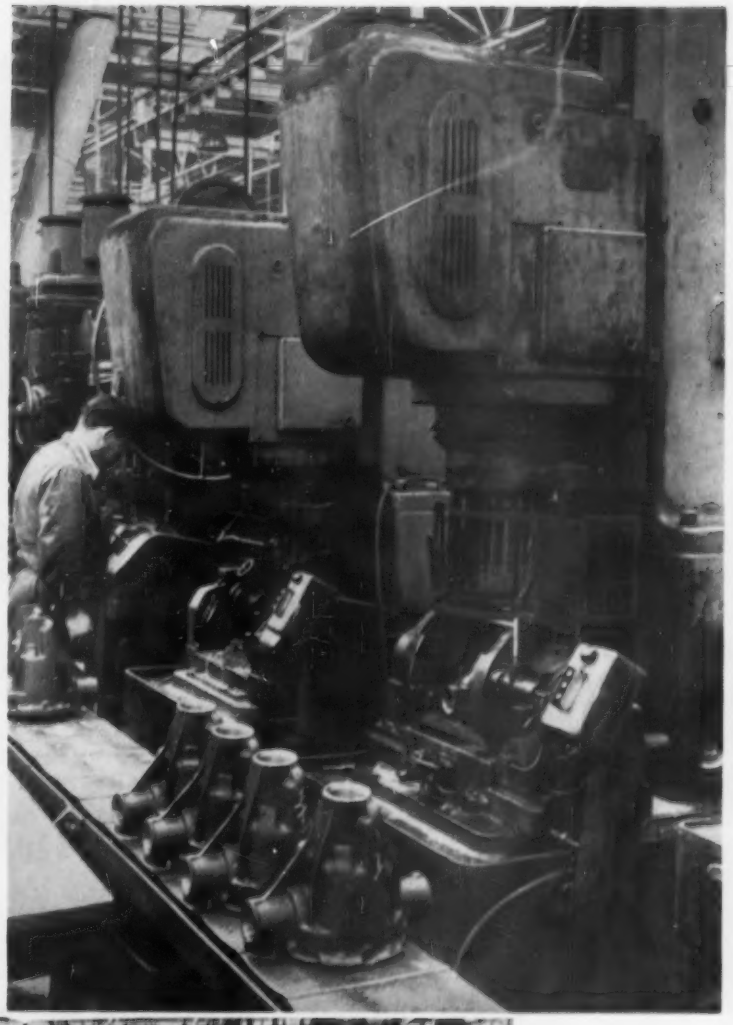

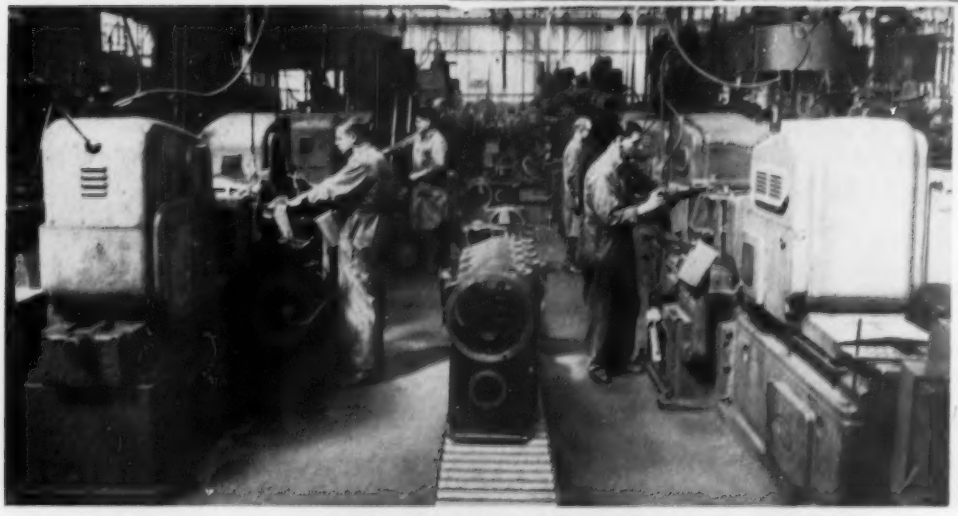

Above: Drilling and Tapping Hypoid Housings for the Standard Vanguard on Asquith Vertical Unit Head Machines.

Below: Drilling and Tapping Centre Housings for the Furguson Tractor on Asquith Horizontal Unit Head Machines.

Photographs by courtesy of The Standard Motor Co., Ltd., COVENTRY.

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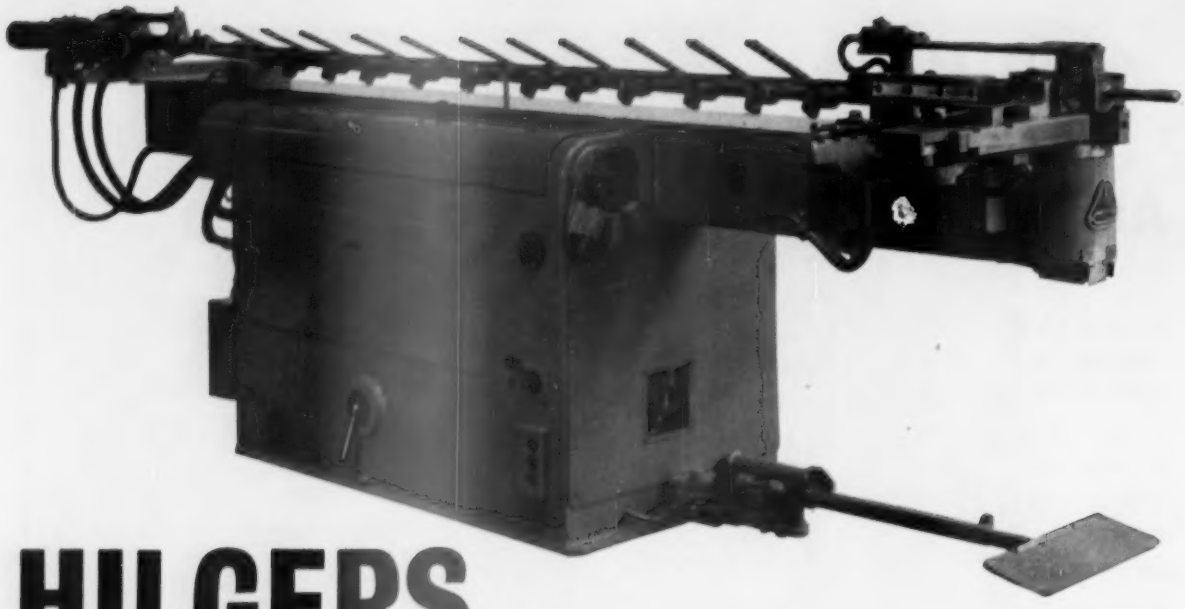

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Number of bends per hour.....up to 250

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Largest tube diameter	approx. 2" o.d. x 5/64" thick	approx. 2¼" o.d. x 5/64" thick
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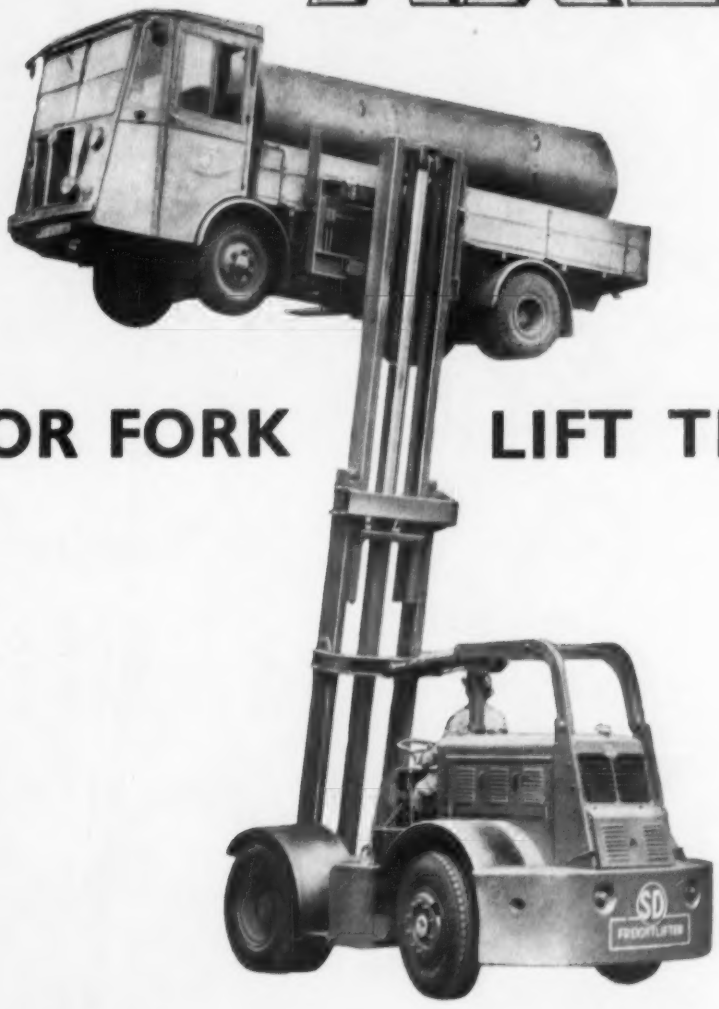

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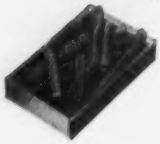
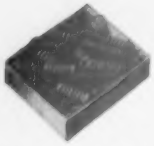
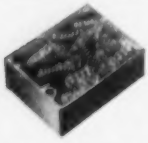


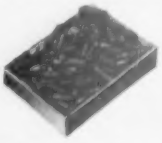
No. 760. 3 doz. Assorted Light Compression Springs 1" to 4" long, 22 to 18 S.W.G., ¼" to ½" diam. 6/6 each.



No. 98A. 3 doz. Assorted 1" to 4" long, ¼" to ⅝" diam., 19G to 15G. 5/6 each.

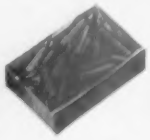


No. 757. Extra Light Compression, 1 gross assorted, ½" to ⅝", ¼" to 2" long, 27 to 20 S.W.G. 15/- each.

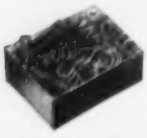


No. 388. ½ gross Assorted Small Expansion Springs. ⅝" to 1½", 18G to 21G. 9/6 each.

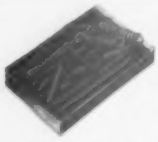
No. 758. Fine Expansion Springs. 1 gross Assorted ½" to ⅝", ¼" to 2" long, 27 to 20 S.W.G. 15/- each.



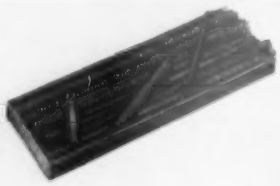
No. 466. ½ gross Assorted Small Expansion Springs ½" to 1¼" long, 3/32" to 3/16" diam., 21G to 24G. 6/6 each.



No. 1024. 20 Compression Springs 12" long. ½" to ¾" diam. 24G to 18G, suitable for cutting into shorter lengths; and 30 Expansions 1½" to 12" long. 5/32" to ⅝" diam., 22G to 16G. 24/- each.



No. 753. 3 doz. Assorted Light Expansion ½" to ⅝" diam., 2" to 6" long, 22 to 18 S.W.G. 10/6 each.



No. 1013. 1 gross Small Coil Compression Springs, ½" to 1¼" long, 3/32" to ¼" diam., 24G to 19G. 6/- each.

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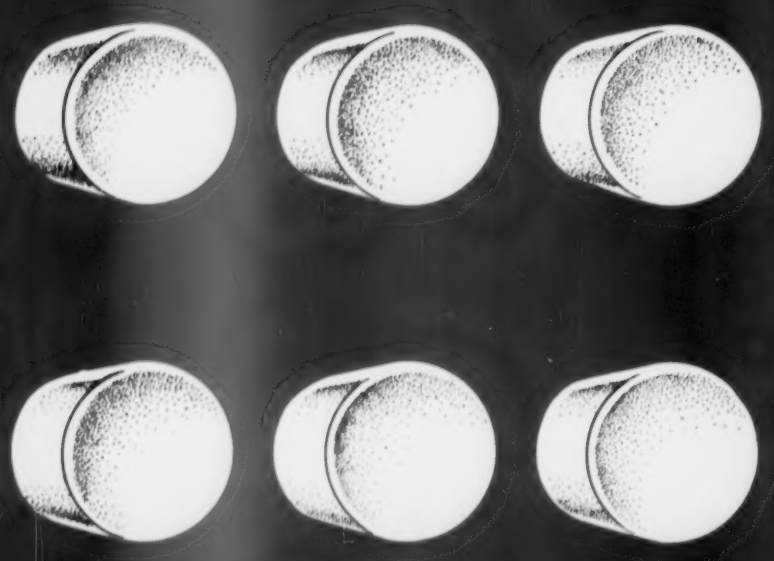

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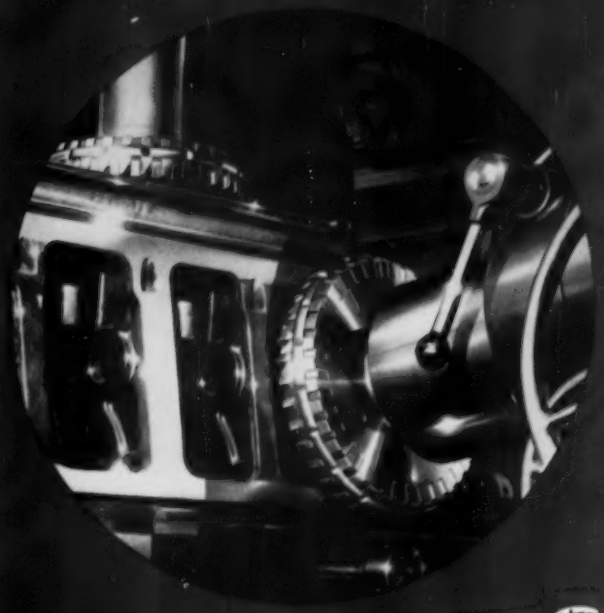

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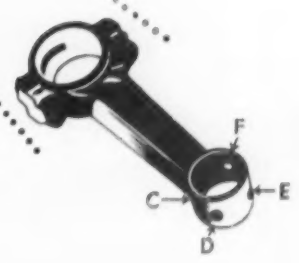
Patent No. 710335 and Patents applied for in all countries.



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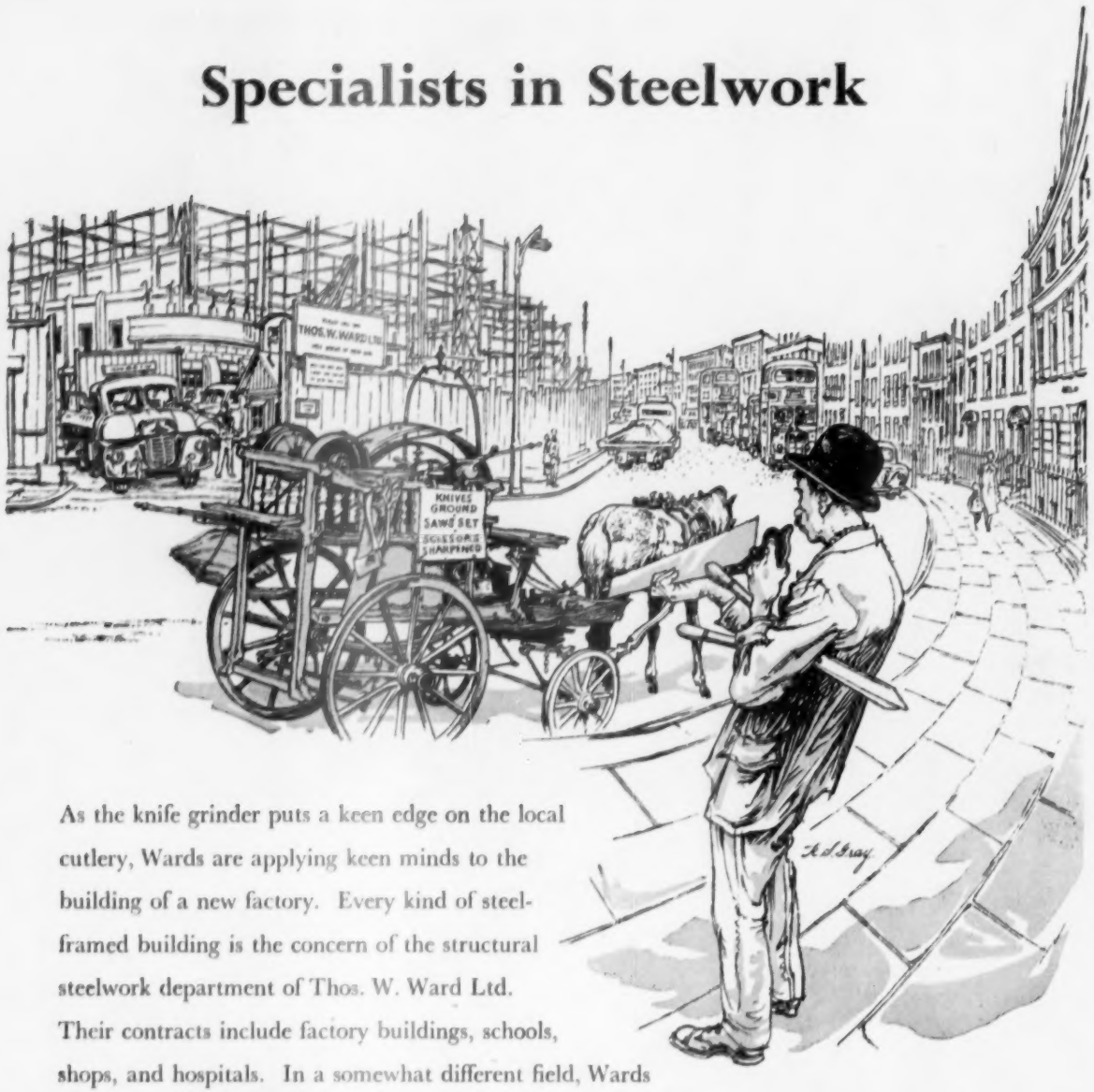

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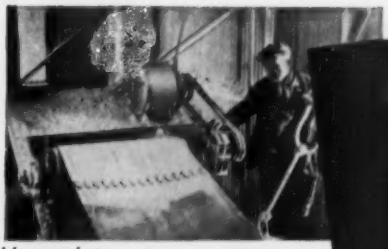
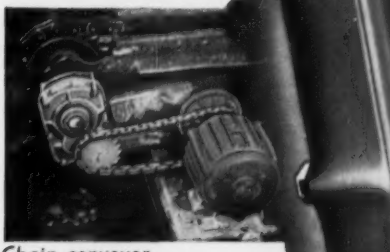
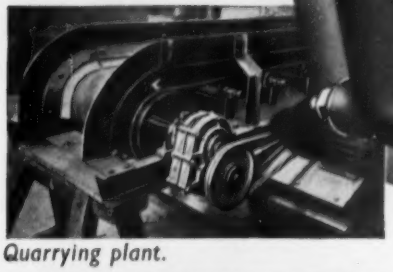


Heavy duty quarry conveyor.

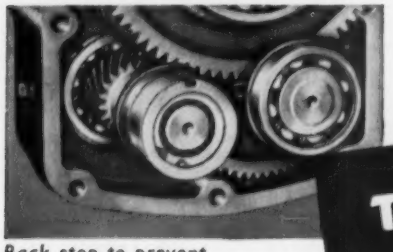
Paint and ink mixer.



Chain conveyor.



Quarrying plant.



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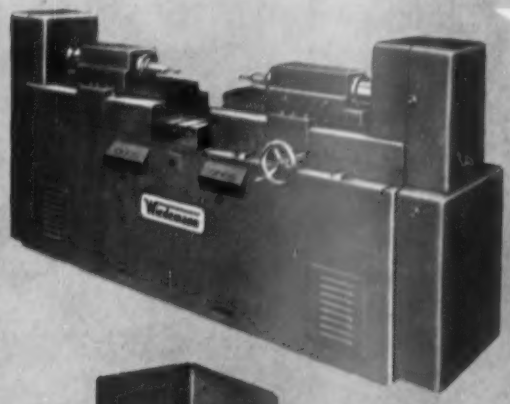

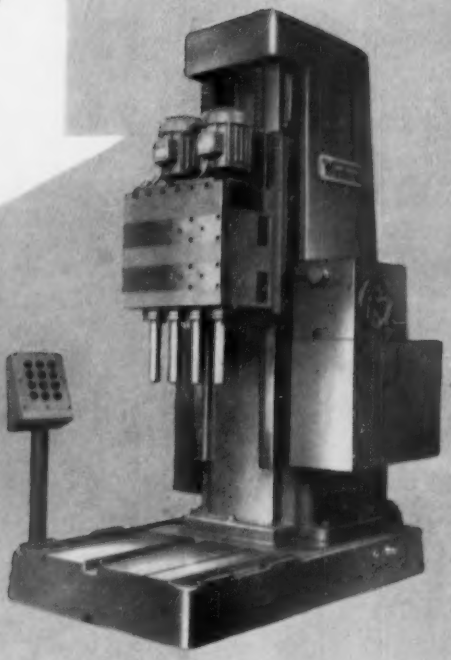

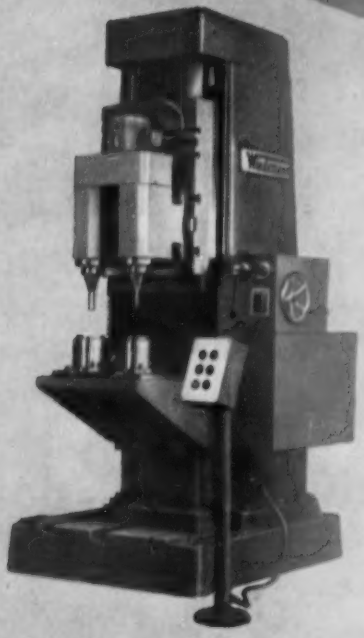

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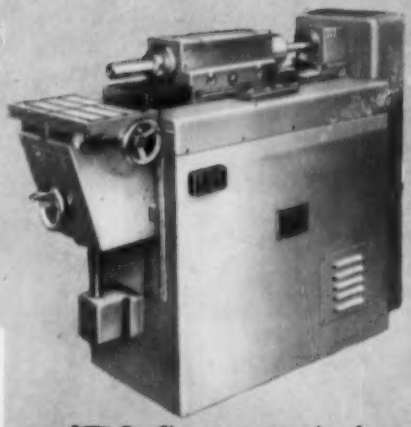

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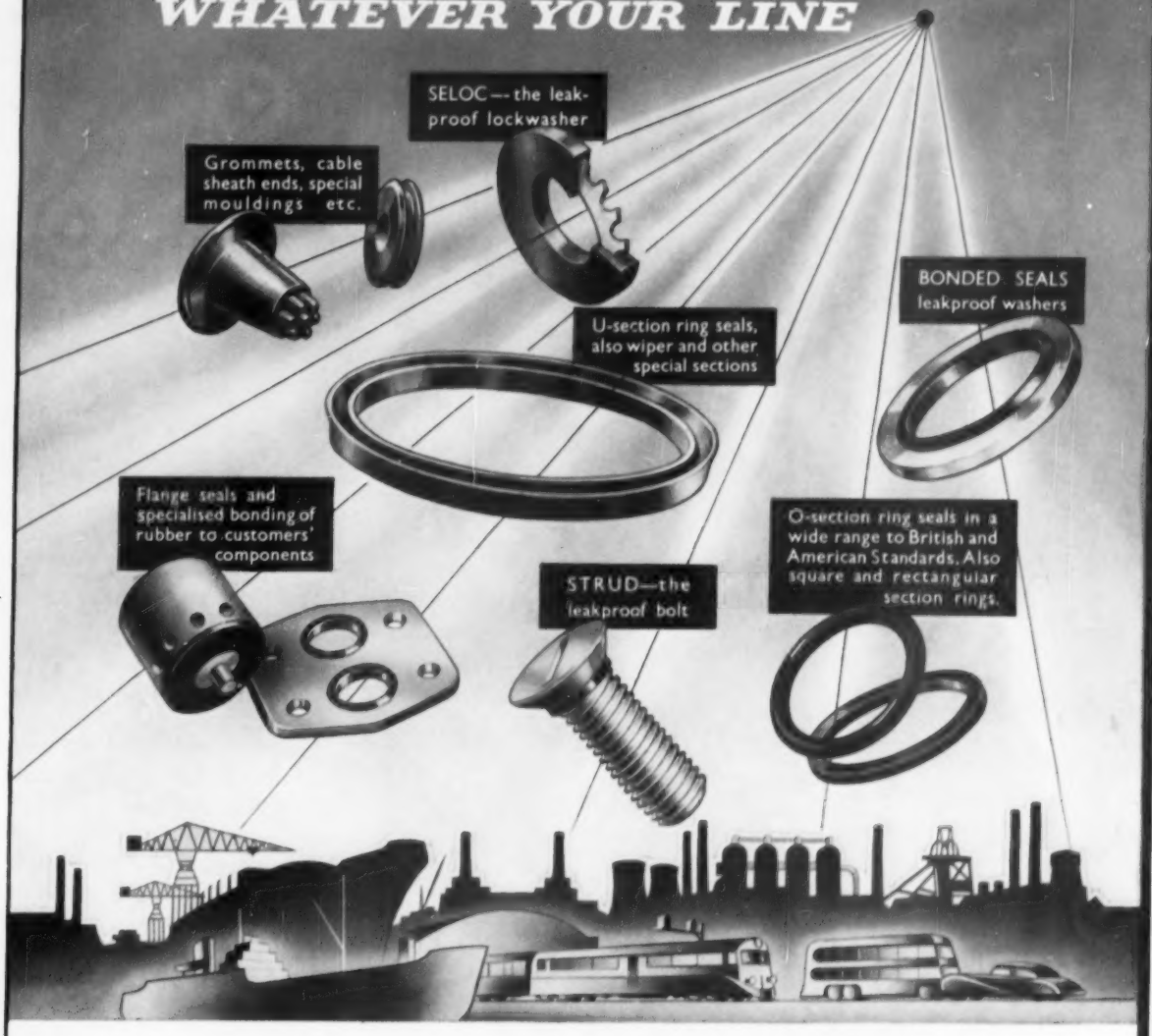
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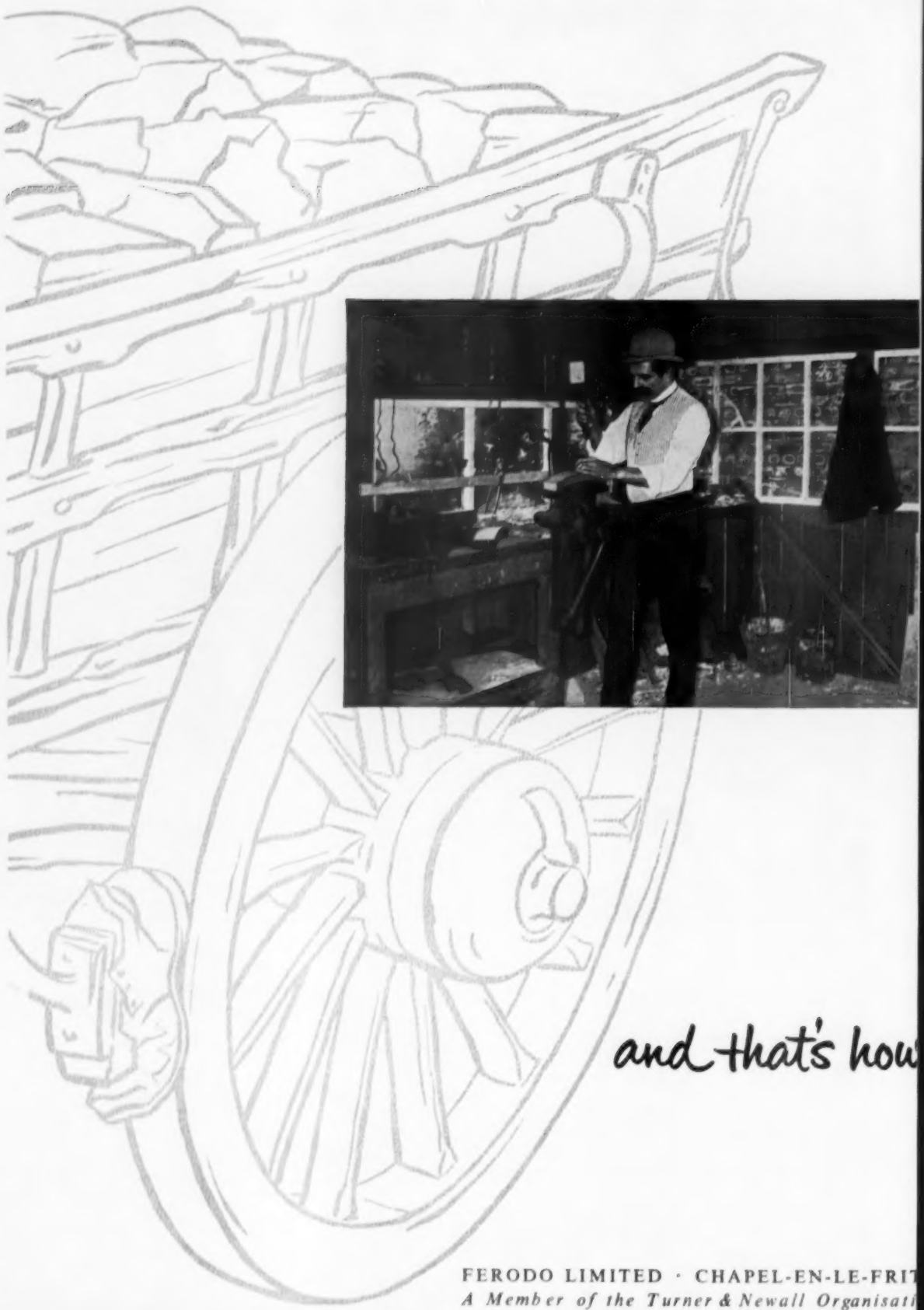

and that's how

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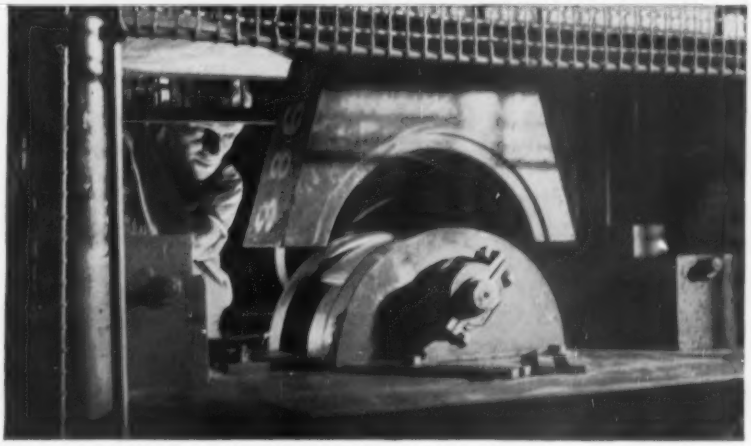
Some things remain

In the long metamorphosis from the small shed in which Herbert Frood founded Ferodo, to the great, uniquely equipped factory of today, some basic characteristics have remained.

Frood had an eager, inquiring mind; after his original inspiration, gained by watching farm carts negotiating the steep hills of his native Peak district, he was always looking for ways to add to the efficiency and safety of the braking materials he developed.



This spirit of research lives on at Chapel-en-le-Frith. In the laboratory and Test House of the Ferodo factory, scientists and technicians still search for new materials, new methods of manufacture, new standards of safety and dependability. Whatever developments may come in the automobile industry, you may be sure that Ferodo Limited will have friction materials ready to match them.

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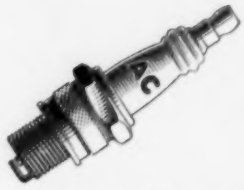
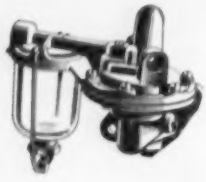
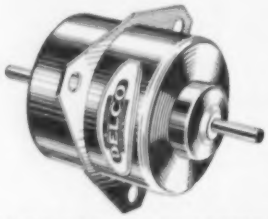


AC SPARK PLUGS



AC FUEL PUMPS



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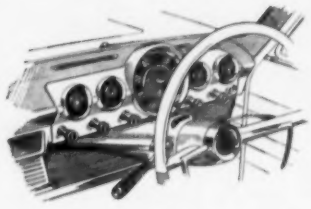

AC INSTRUMENTS

Virtually every British car has one or more AC-Delco components designed into it on the drawing-board. AC-Delco research engineers will gladly help when you are planning a new design or modifying an existing one. Liaison at the drawing-board stage can help your design and production programme.

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AC-DELCO DIVISION OF GENERAL MOTORS LIMITED, Dunstable, Beds. Telephone Dunstable 1166
or Broadgate House, Coventry. Telephone Coventry 40491

I·F·S

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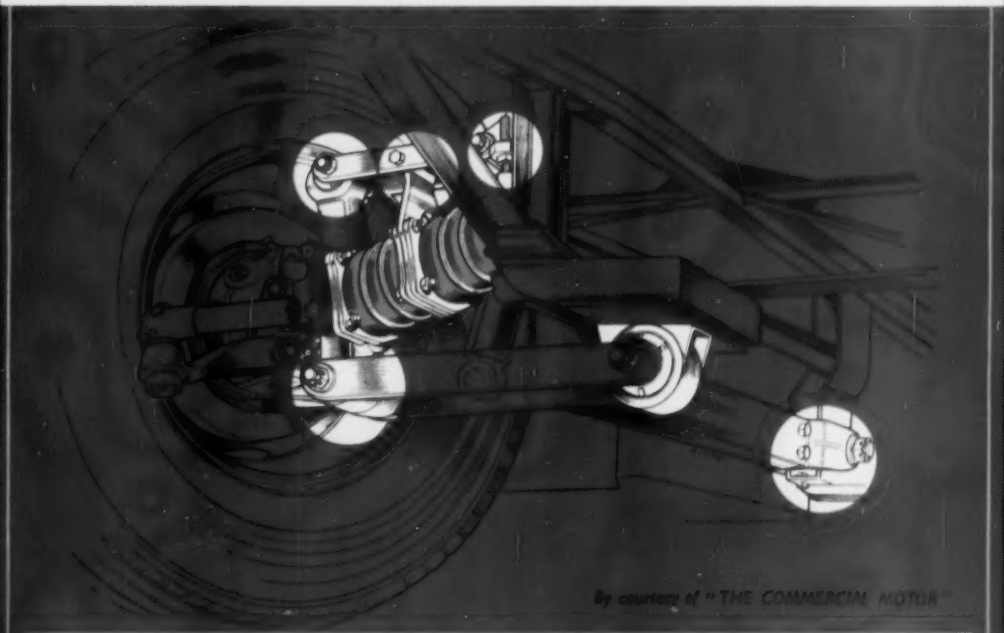

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as adopted on the new Midland Red bus, is yet another advance made possible by utilizing the qualities of properly engineered rubber, not only to eliminate all metal-to-metal bearings from the suspension, but also to attain, in a practical and compact form, that long-sought ideal in a public service vehicle suspension, a variable spring rate.

This I.F.S. system, using direct-loaded Metalastik rubber springs, also utilizes (in the articulated joints) "Spherilastik" bearings, and Metalastik Ultra-duty bushes and inner-sleeve bushes.

Our engineers are at the disposal of all who are interested in the modern uses of rubber.

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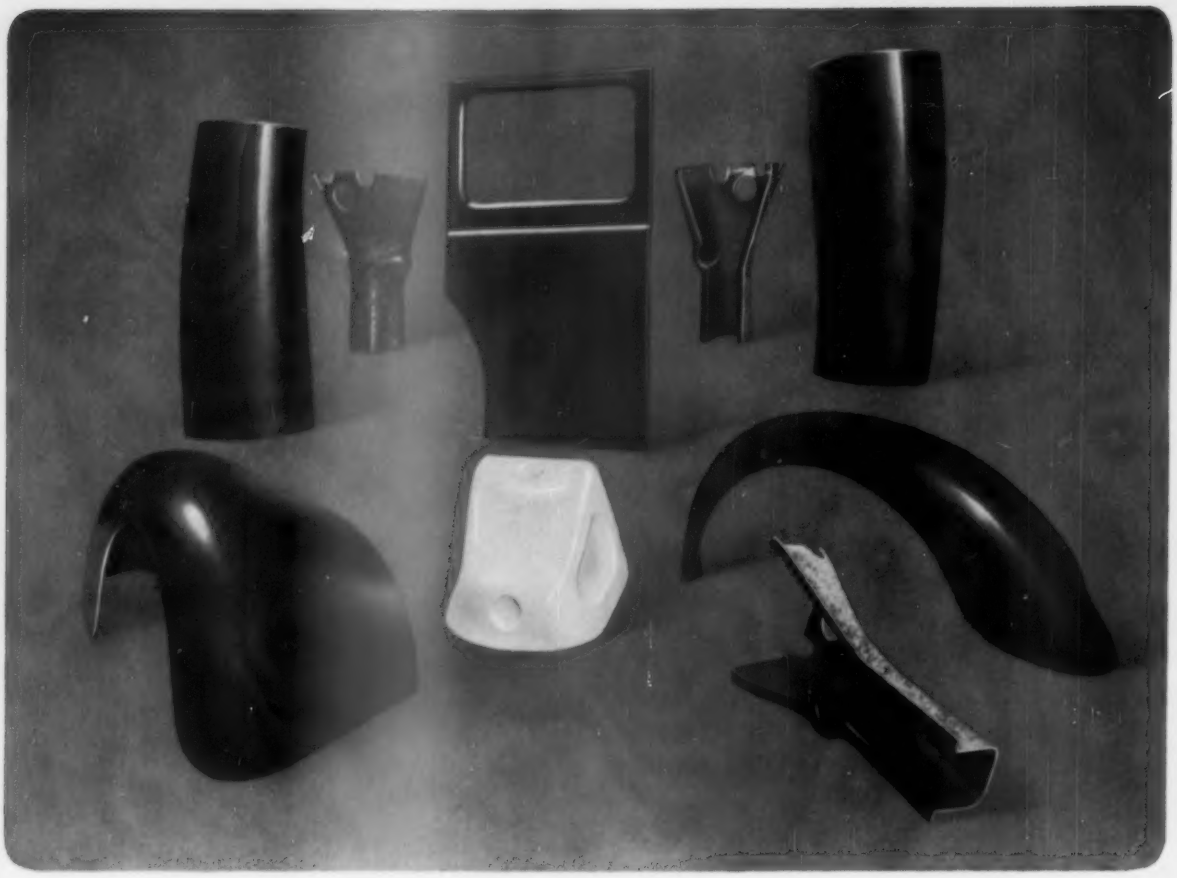

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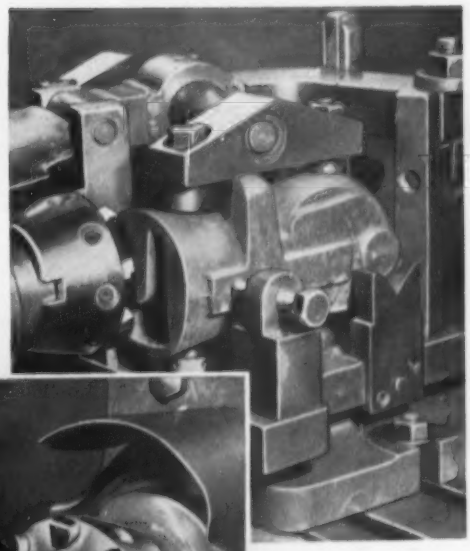
Improved manufacturing facilities have reduced production costs enabling us to reduce prices. Thus, the most efficient cutters of their type are available at prices competitive with other well-known makes.



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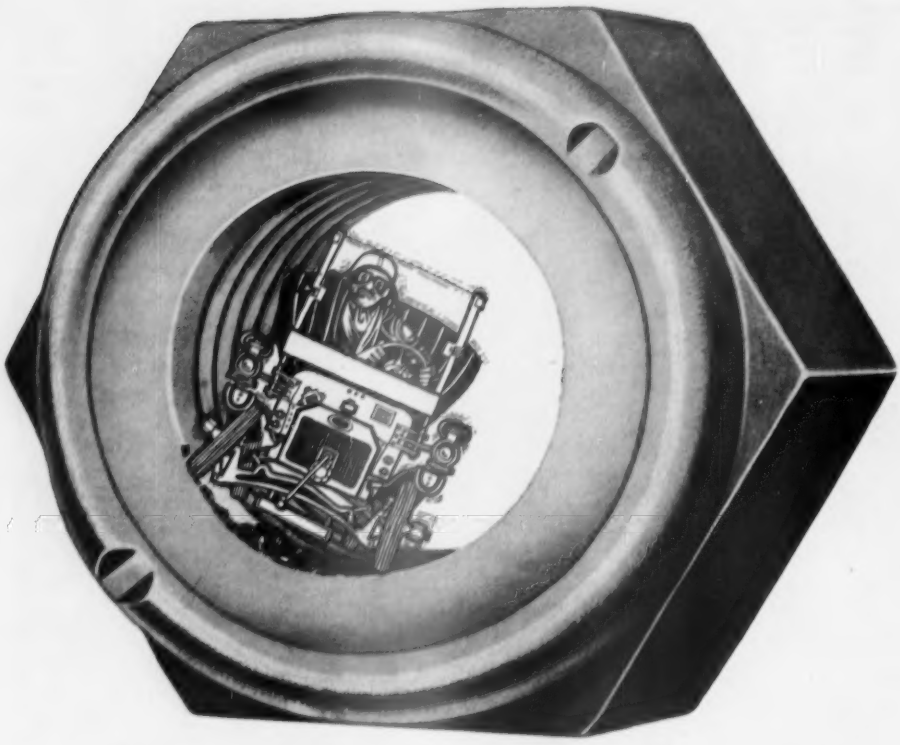

. . . but nothing rattles the NYLOC

In the BMC Series 'C' 6 cylinder engine — basic power-unit of the Austin A 90 Westminster, the Wolseley 6/90 and the Morris 'Isis' — Nyloc nuts are fitted to the connecting rod big-end bolts and the main bearing caps. Once fitted, they don't budge a thou — despite piston speeds of around 2,630 feet per minute and explosion stresses of 5 tons per square inch! And by using Nylocs instead of the time-wasting split-pin method Morris Motors Ltd., (Engines Branch) have speeded up production and made sure of a correct assembly *every* time.

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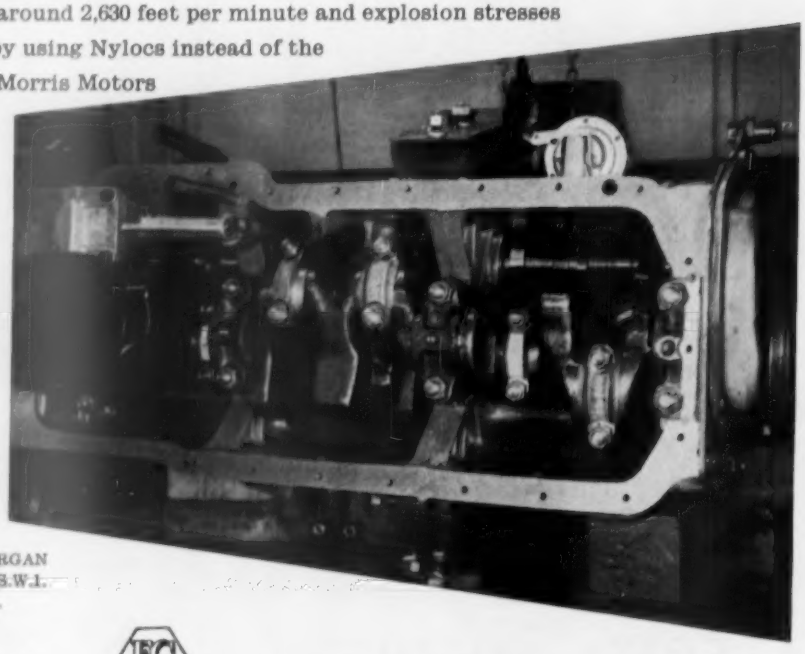

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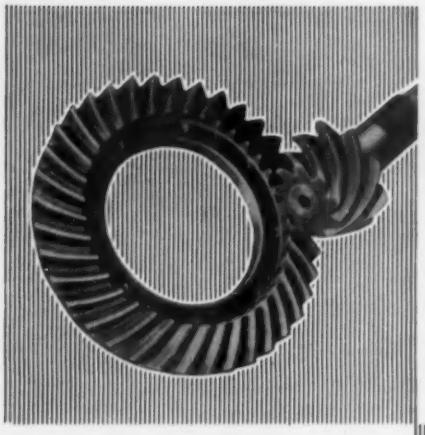
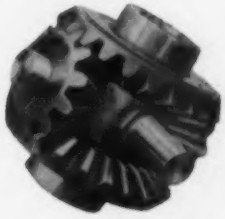
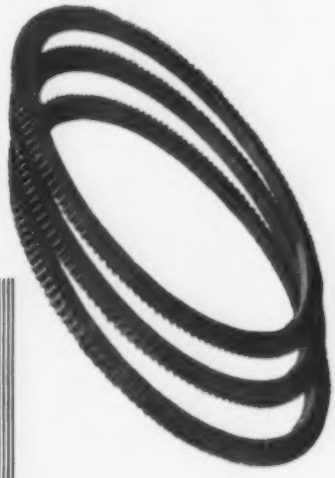
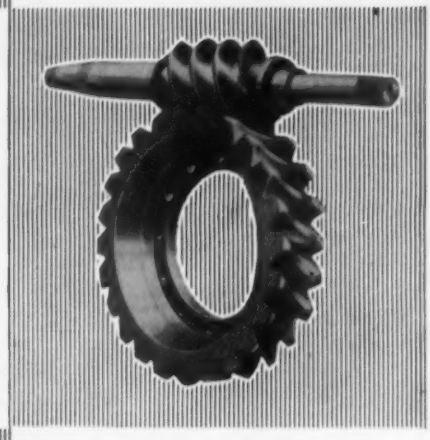
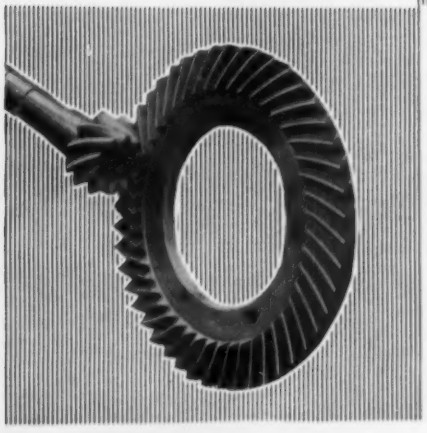


WHATEVER THE DRIVE









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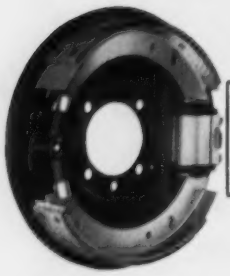
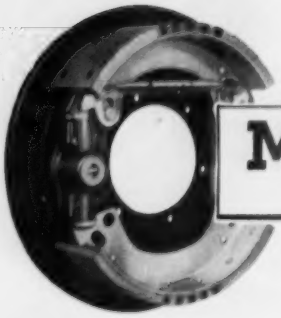


LIGHT
duty



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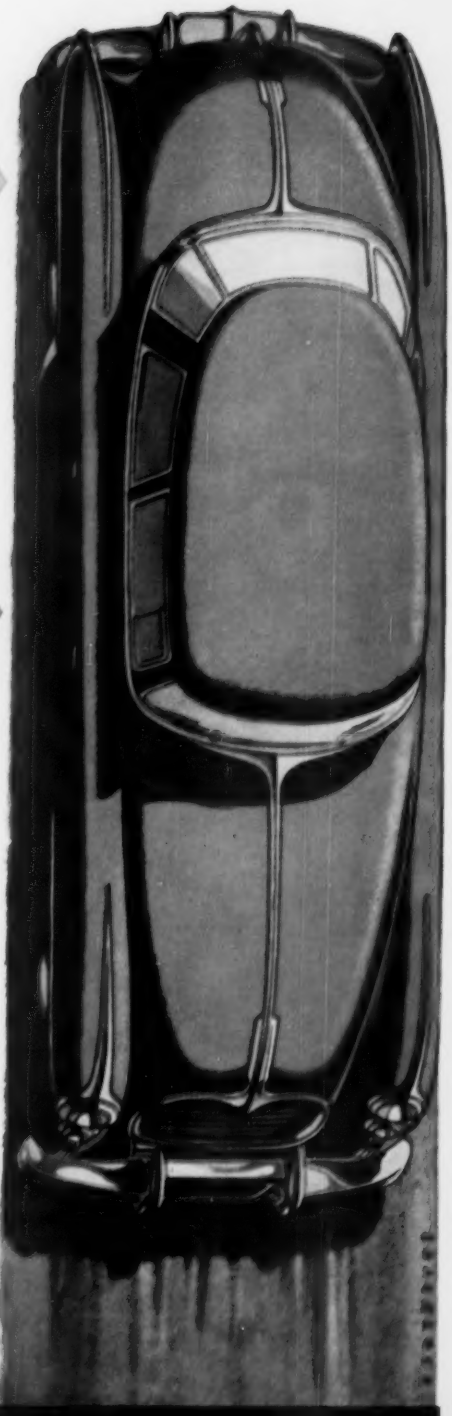

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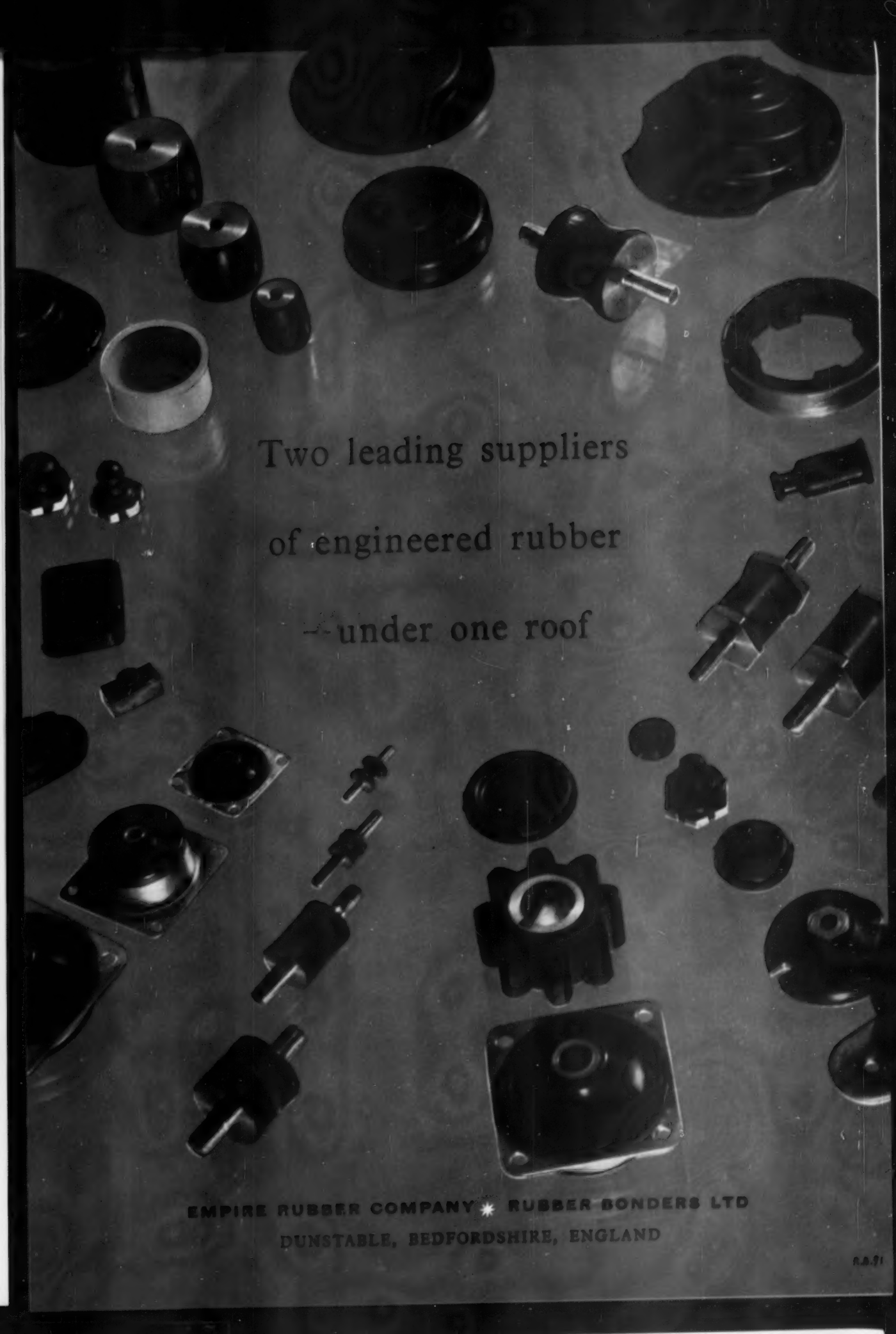
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No matter how high the power or how high the R.P.M; Layrub transmission is supreme.

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Here then is a transmission system designed for modern times—a drive shaft that can be installed and almost forgotten.

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TRANSMISSION at it's best

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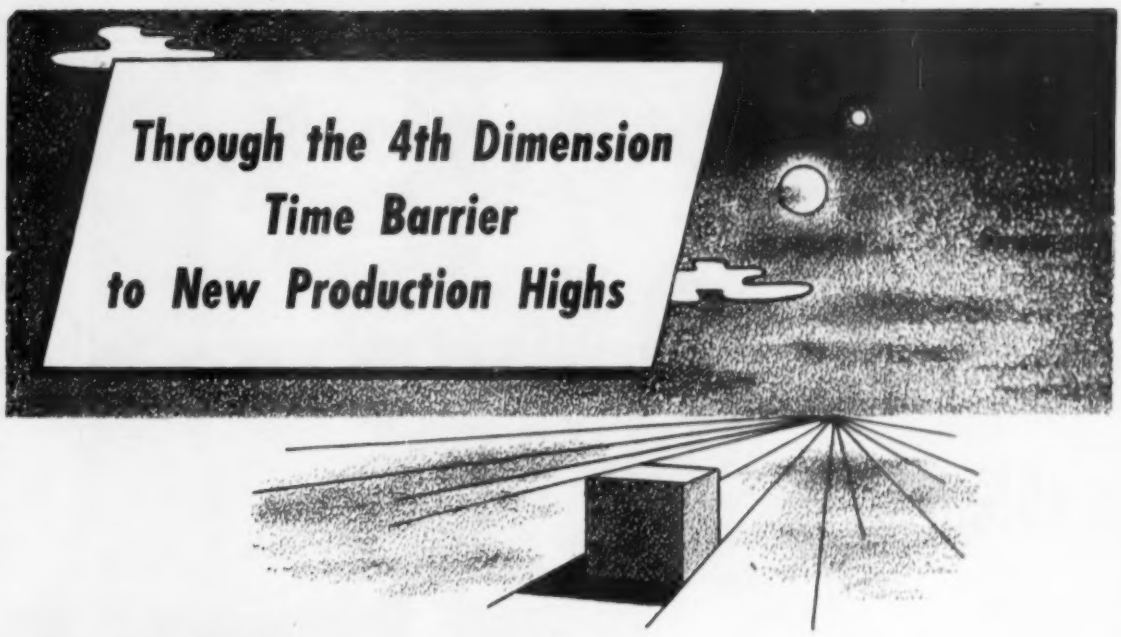

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gears machine production to the steady flow of Time

All industrial results are achieved in Time—vital Fourth Dimension that measures output, costs, profit. Shorten the time gap between operations—shorten the time when machines are "cutting air" — keep machines producing at a steady optimum rate during the fatigue slow-down from 10.30 to noon, and from 3 p.m. till closing time—and you are getting Fourth Dimension production. Production that is geared to the steady flow of Time.

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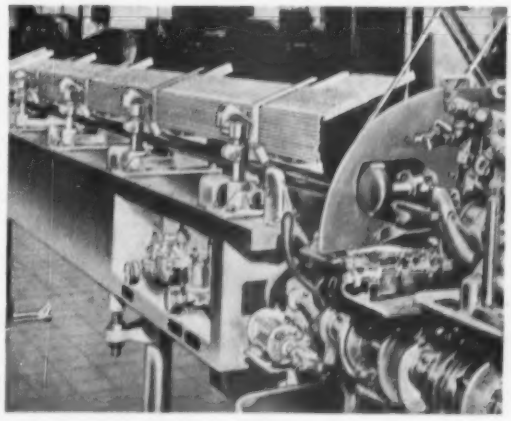

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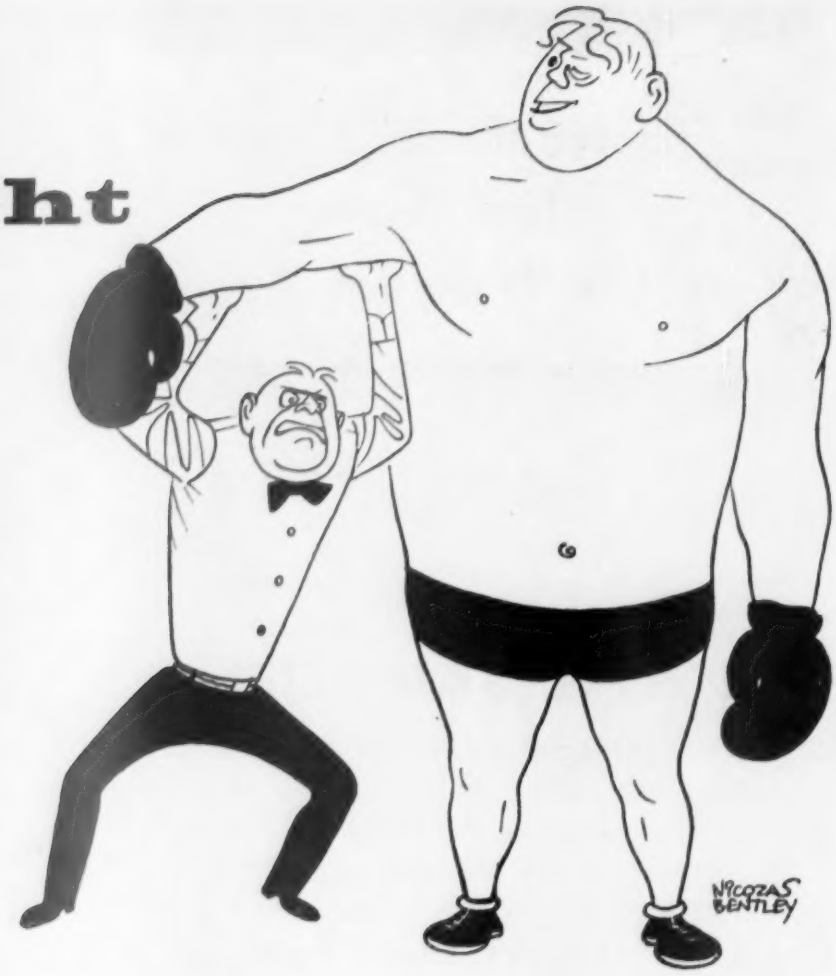
When **weight** is a problem



The verdict in industry is always the same. Reduced weight—say, in transport or building—can mean greater all-round efficiency and economy. The question is: how can weight be reduced without loss of strength?

More and more, 'Kynal' wrought aluminium alloys are providing the answer. There is scarcely a branch of industry today where they are not used. The reason is that they are light and yet very strong and durable. They are made by I.C.I. Metals Division—that is proof enough of their quality. For the usual rigid technical control during production ensures that they will stand up to the most rigorous conditions.

Have you a weighty problem? If so, let 'Kynal' solve it for you.

'KYNAL' AND 'KYNALCORE' wrought aluminium alloys are already extensively used in the following industries:

Aircraft: *ribs, spars, engine components, stressed skin covering, fittings, etc.*

Railways: *structural members, roofing, panelling, windows, luggage racks, etc.*

Road Transport: *structural members, floor planks and panelling, windows, tread strips, doors, small fittings, etc.*

Shipbuilding: *bridges, wheelhouses, outer funnels, skylights, decks, stanchions, bulkheads, watertight doors, lifeboats and davits, etc.*

Building: *roof coverings, side claddings, ventilators and windows, panelling, interior fittings, etc.*

'KYNAL' AND 'KYNALCORE' WROUGHT ALUMINIUM ALLOYS

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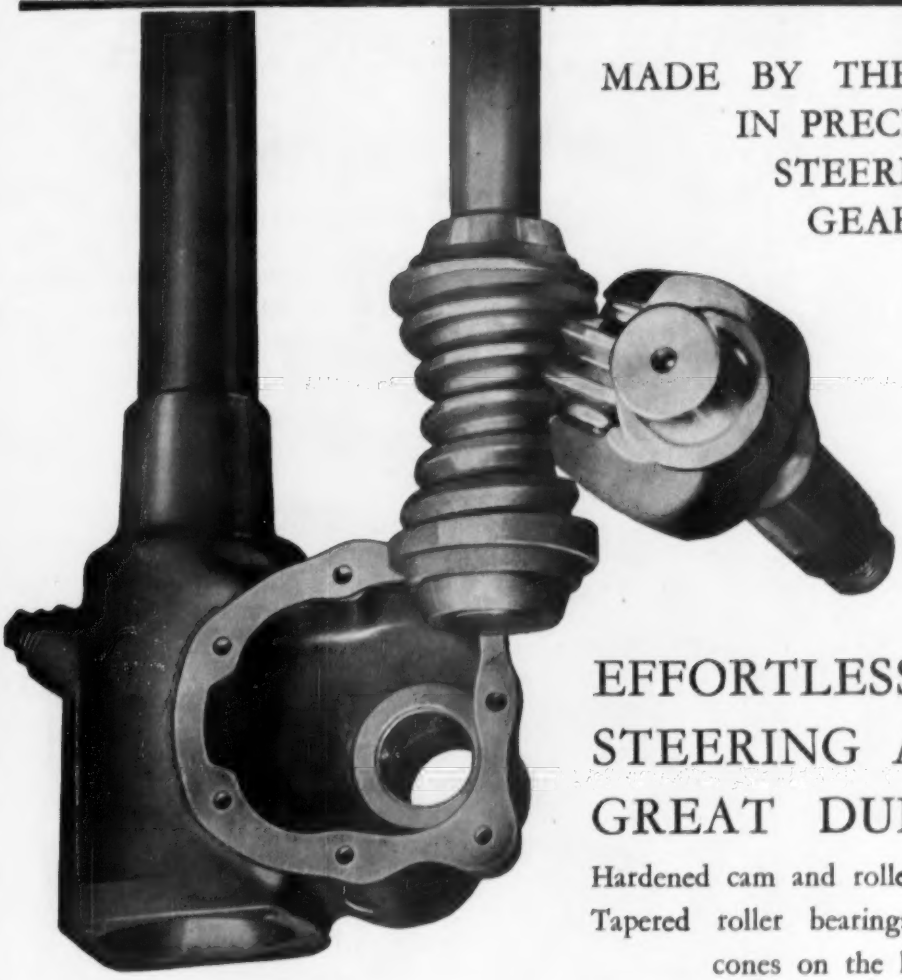

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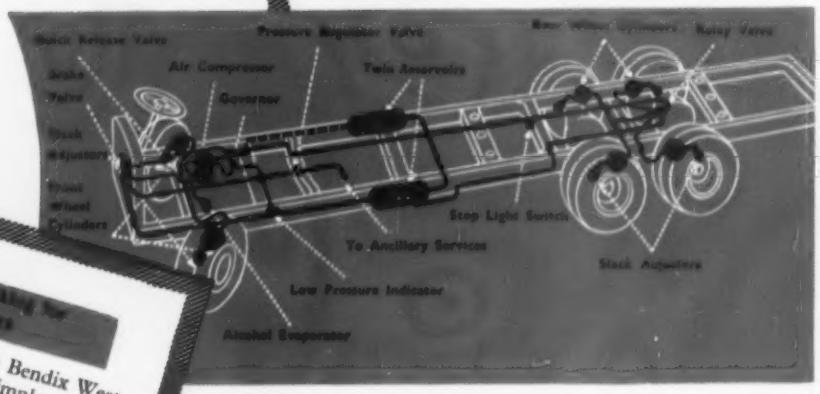

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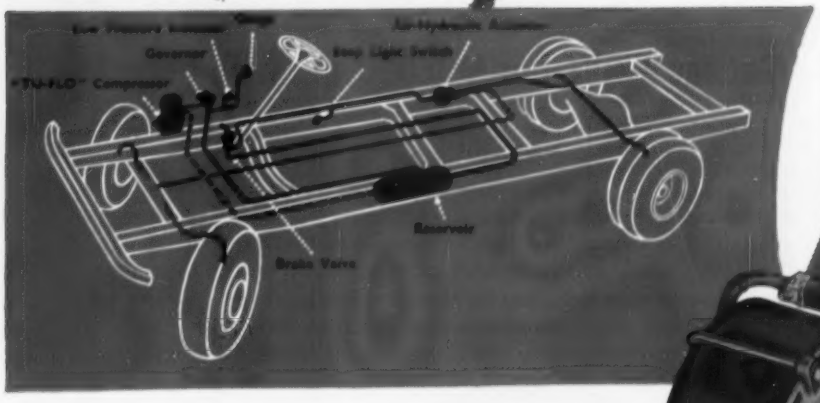

Clayton Dewandre are now producing this up-to-the-minute range of American equipment for all types of vehicles in addition to their own world-renowned Vacuum and Air Pressure Braking systems.

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Just what is the difference between woven and molded brake liners? Most important of all, the way one type can "cure" braking idiosyncrasies that would be aggravated by the other—and vice versa. That's the advantage of the DON range: in it there's a woven ***or*** molded quality to solve squeal and every other problem in any braking system. And to make sure the *right* DON liner is selected for every job, there's a nation-wide chain of DON depots—each one staffed by people who know their job. *It pays therefore to...*

Fit **Don** BRAKE LINERS *to be sure!*

The best of Woven and Molded

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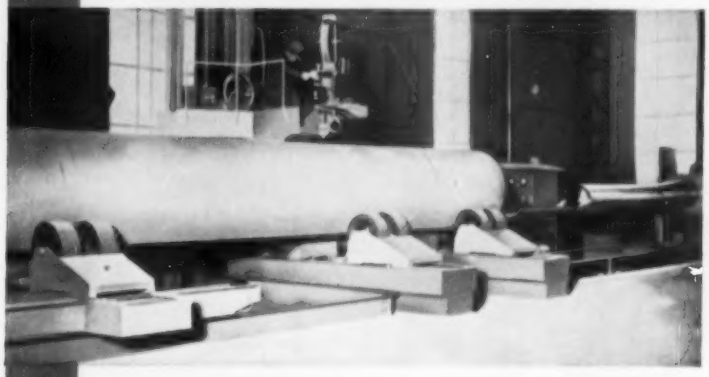

External and internal welding of Class 1 boiler drums, by the Fusarc process. Note the versatile cantilever—supported automatic welding head; boom-type internal welder (right) with effective welding traverse of 15' 0"; and the adjustable motorised roller bed, working in conjunction with an idler-bed unit. All manufactured, installed and serviced by Quasi-Arc Limited—and only one of many complex automatic welding installations now in production.

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The biggest-selling continuous covered electrode process in the world—and in its field the most economical. Fusarc with its visible arc, runs fast and efficiently, and gives excellent results both indoors and outdoors.

Unionmelt
The world-renowned submerged arc process, giving X-ray sound welds with perfect finish. There is no spatter and no flash. It is rapidly expanding into light plate welding as well as in heavy fabrication work.

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have been combined in order to provide a thoroughly comprehensive and effective service to the welding industry.
The headquarters of the new organisation—named Quasi-Arc Limited—are at Bilston, Staffordshire, with works at Bilston and Gateshead.

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New C.A.V. Paper Element Fuel Filter

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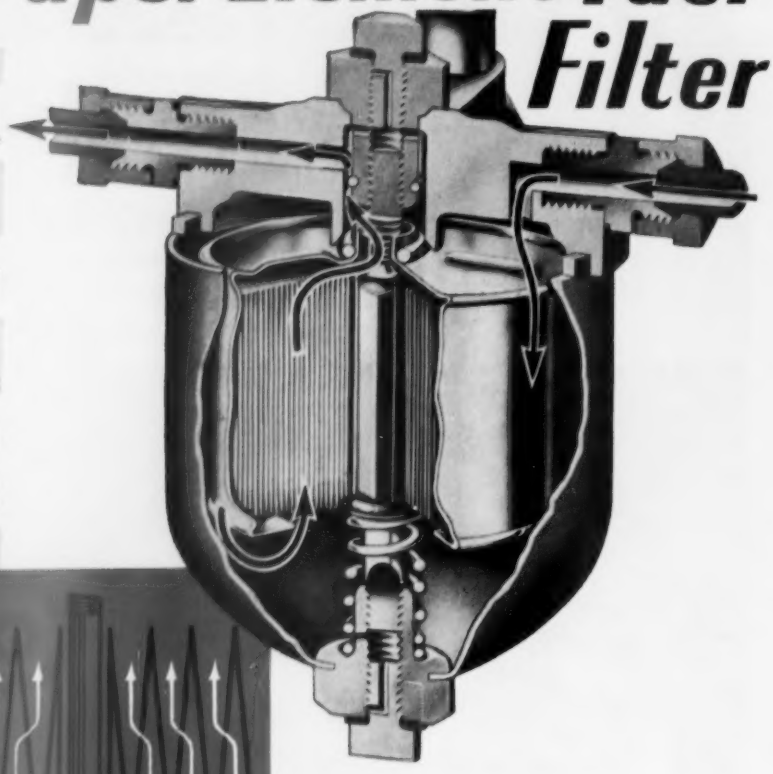
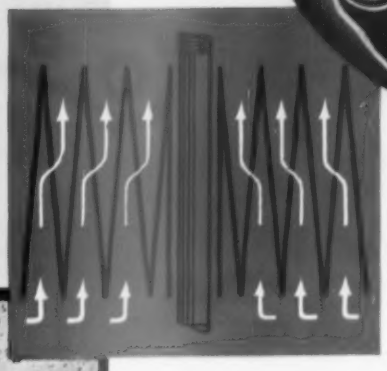
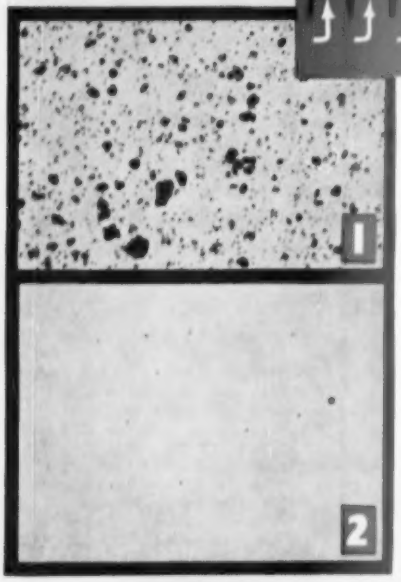
Highest efficiency

Minimises wear on injection equipment







Clean fuel gives up to 8 times pump life

Research shows that fuel pump and injector wear are largely caused by fine, abrasive dust carried in the fuel, and that if fuel is clean, pump wear is negligible. The new C.A.V. type 'F' filter with the spiral vee-form paper element is designed to remove the minute particles from fuel, that will entirely escape an ordinary filter. The photomicrographs show (1) fuel as supplied (approx. x 100), and (2) the fuel after filtering with the new element (to same scale).

The centre illustration shows diagrammatically the principle of the spiral vee-form element, and the path taken by the fuel. Note the large filtering area, 560 sq. inches in all, many times that of most filters; yet the new filter is only two-thirds the size of the corresponding cloth or felt filter.

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for casehardening heat-treatment brazing . . .

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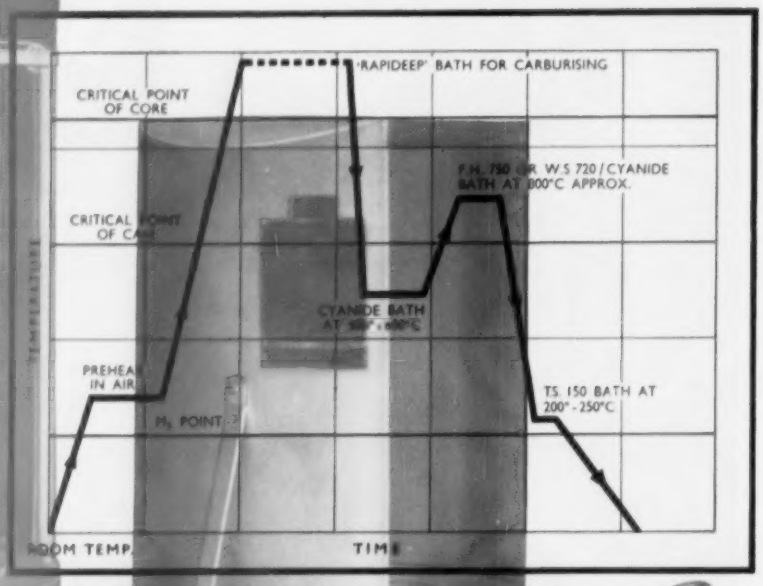
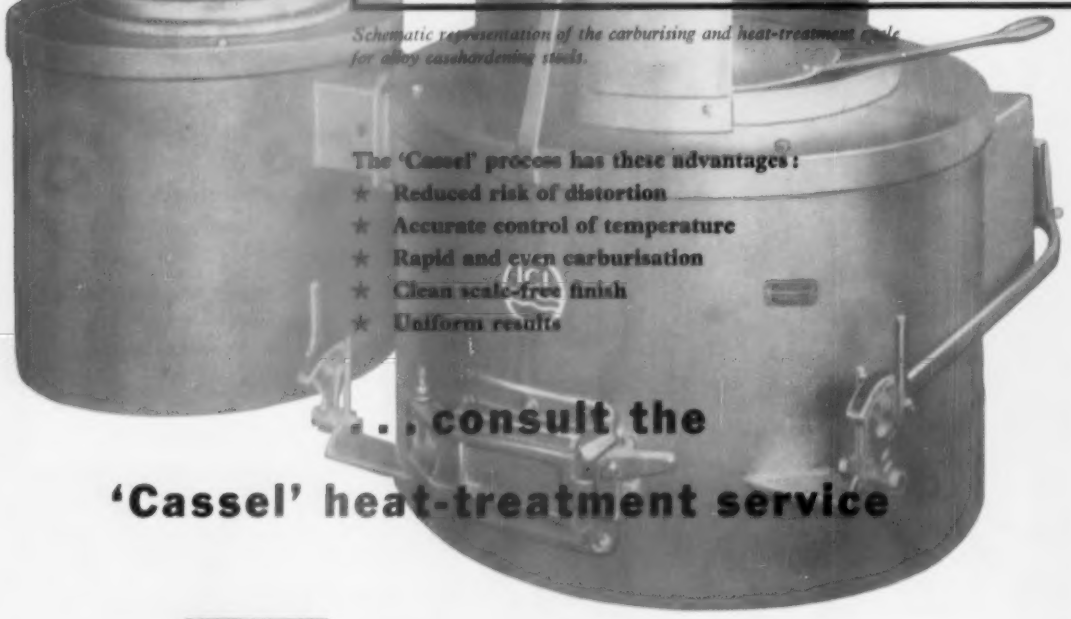


Schematic representation of the carburising and heat-treatment cycle for alloy casehardening steels.



The 'Cassel' process has these advantages:

- ★ **Reduced risk of distortion**
- ★ **Accurate control of temperature**
- ★ **Rapid and even carburisation**
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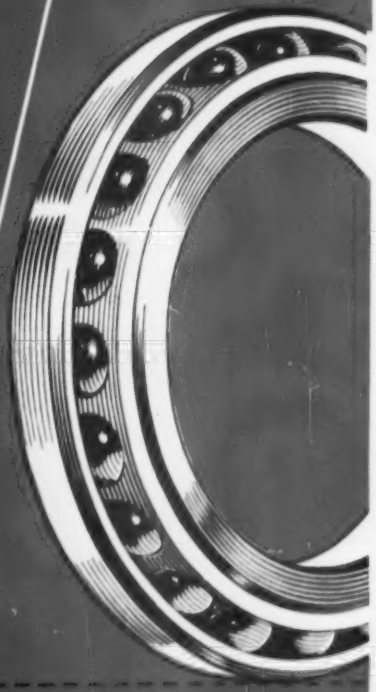

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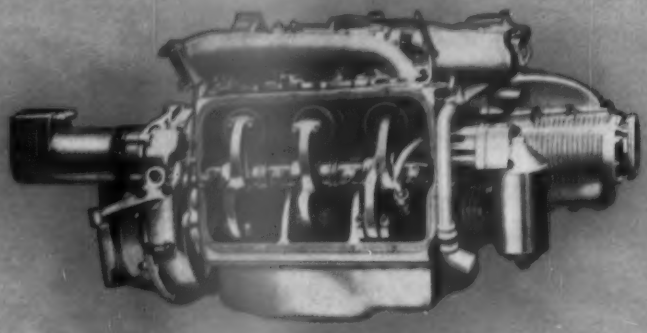
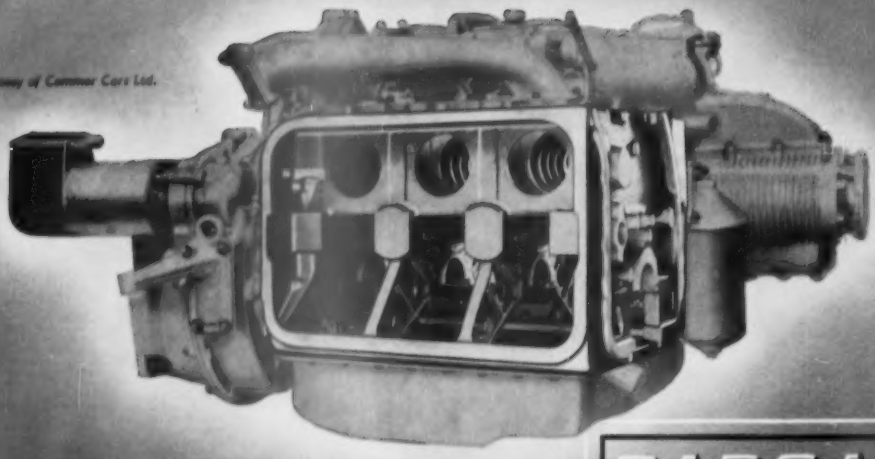


Highly mechanised methods are used for the rapid production of this cast iron Crankcase for the Commer T. S. 3. diesel power unit. In the unmachined state it weighs no more than 284 lbs. The design has eliminated masses of power wasting metal and has produced a lighter and more compact engine with greatly improved power weight ratio.

A FINE ENGINE built round A FINE CASTING

By courtesy of Commer Cars Ltd.



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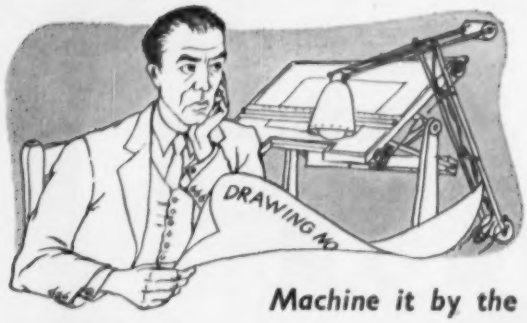
Too hard or intricate for conventional methods?



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SPARK EROSION

SPARCATRON Mk. II equipment with twin heads. A further two or more heads may be used in conjunction with the main control unit (left), in some circumstances. An essential to the process is the electrode having the male form of the shape to be cut in the workpiece. This can be a work sample, or a pattern in easy to machine material can be made and used to mould electrodes in quantity. In some instances hollow electrodes can be used for piercing and resultant slugs of useful size can be saved. Once set up the process needs only occasional inspection ; one man can operate two or three machines and have time to make and mount electrodes.

Sinking one half of a die in hardened steel. A spare brass electrode rests face up on the die. It can be seen that the base profile and surface contour of the electrode correspond with the impression to be sunk except, of course, that they are reversed.

THE SPARCATRON process of spark erosion provides a long sought means of "cutting" intricate shapes, profiles, forms or impressions accurately and at relatively high speeds in materials which otherwise cannot be machined, or where it is not economic to do so by conventional methods. No matter how hard or tough, any material capable of conducting electric current can be machined with ease by SPARCATRON equipment.

In the toolmaking industries for press tools and dies in cemented carbides and hardened steels the process is firmly established; it has many applications in the making, reconditioning or alteration of dies and moulds for diecasting, drop forging, hot brass stamping, plastics, rubber, ceramics and of wire drawing and extrusion dies.

Like most machining processes, spark cutting can be divided into roughing and finishing operations, but here the changeover can be made instantaneously without interrupting the cutting. The work is not left with a scratch finish as by milling or grinding; starting points for and the development of hair cracks are precluded. The work remains cold during the process so there is no change in structure; hardened steels can be machined with ease and difficulties associated with hardening after machining are eliminated.

SPARCATRON spark erosion may be the answer to *your* machining problems. Permit us to send you further details or to advise on applications to meet your requirements.

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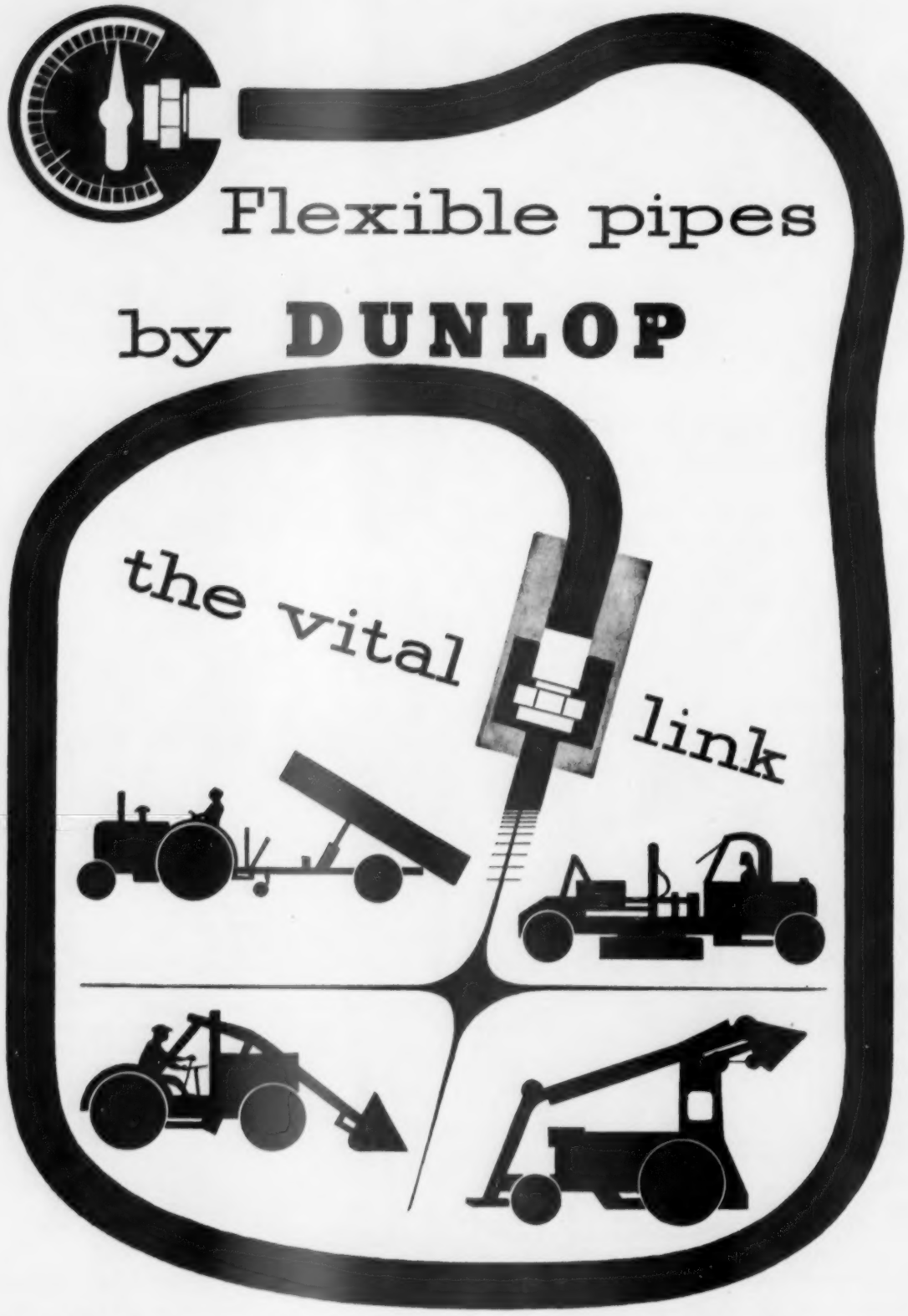

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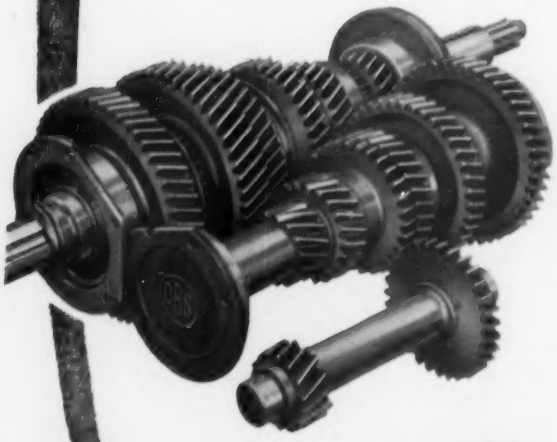
- **Upper half can be removed without disturbing gears or selector mechanism.**
- **Compact forward control unit, connected to gearbox by two universal joints offering flexibility of chassis layout.**

Specification E.393.19, giving complete details, is available on request.

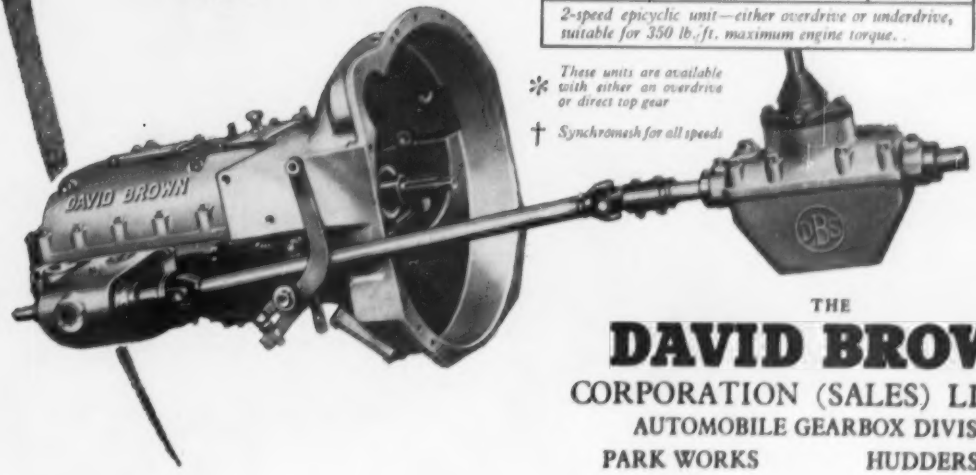


STANDARD GEARBOX RANGE

	Type	Max. Engine Torque (lb/ft)	No. of Speeds
	430C	90	4
	437	133	4
✲	542	205	5
✲	45	250	5
✲	045	250	5
†	S450	300	4
✲	557CM	350	5
	2-speed epicyclic unit—either overdrive or underdrive, suitable for 350 lb./ft. maximum engine torque.		

✲ *These units are available with either an overdrive or direct top gear*

† *Synchromesh for all speeds*



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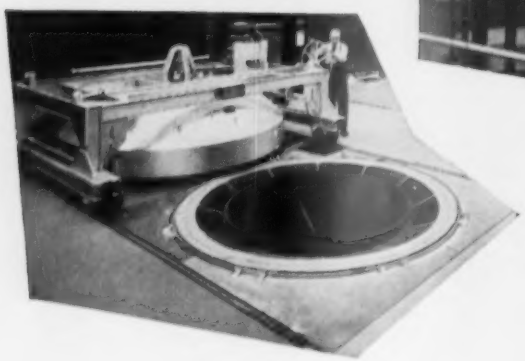

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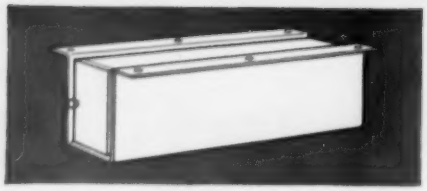

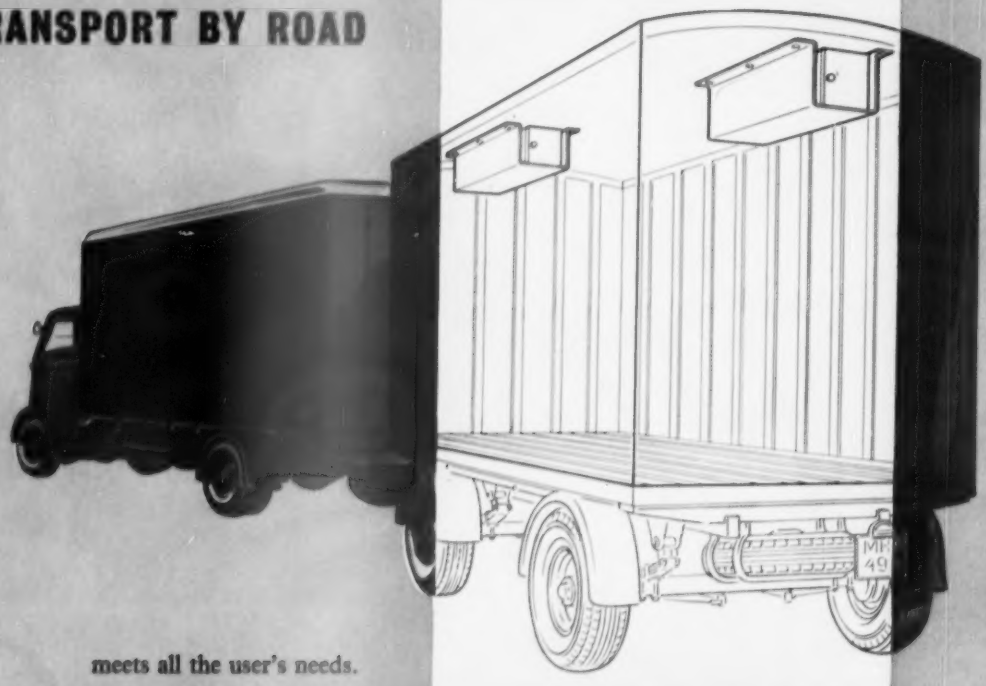

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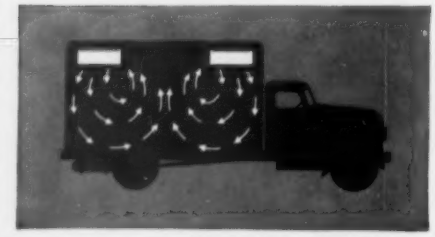

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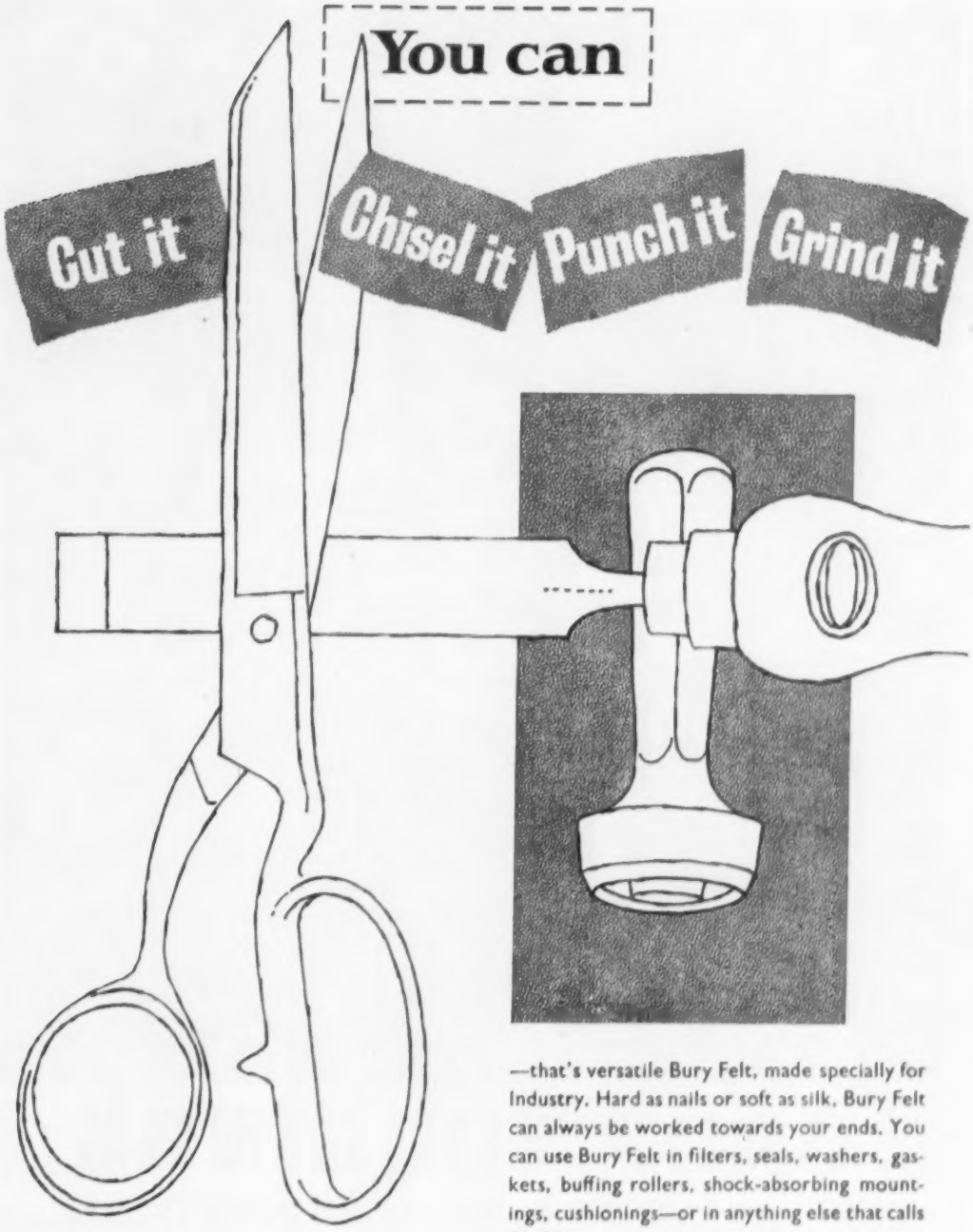

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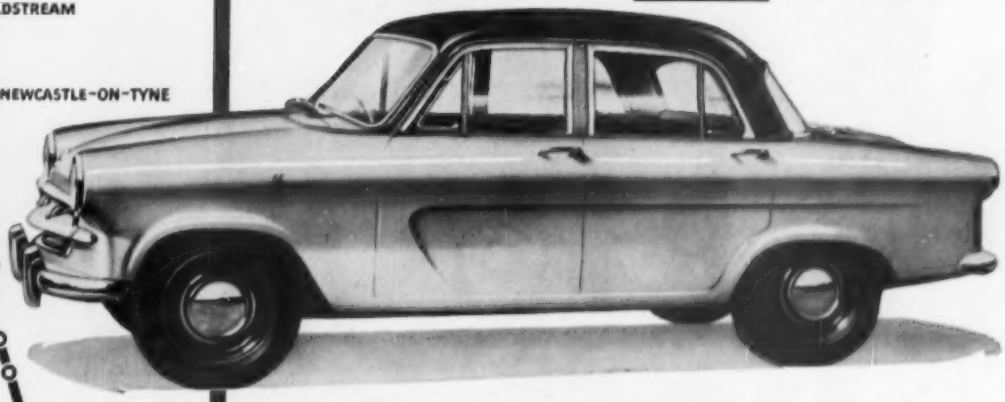

A normal Standard Vanguard III Saloon, chosen at random and fully run-in, recently gave remarkable proof of the fuel-saving possible with the Laycock de Normanville Overdrive. The Vanguard, fully laden, covered the testing 794-mile London-Edinburgh-London route at an average of 37.5 m.p.h. for a fuel consumption of only 34.53 m.p.g. The car was driven normally with appropriate use of the Overdrive and "coasting" was not permitted. Disconcerting "coasting" is in fact not possible with the *Laycock* Overdrive, the car is always under COMPLETE DRIVER CONTROL; this, in addition to its fuel-saving and other advantages, is why the All-British Laycock Overdrive is now available on 30 of Britain's finer cars.

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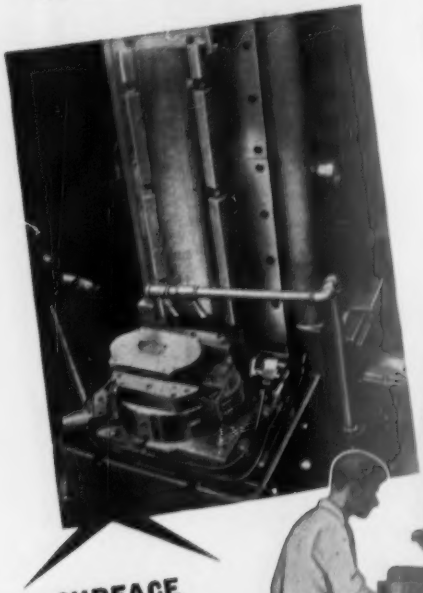

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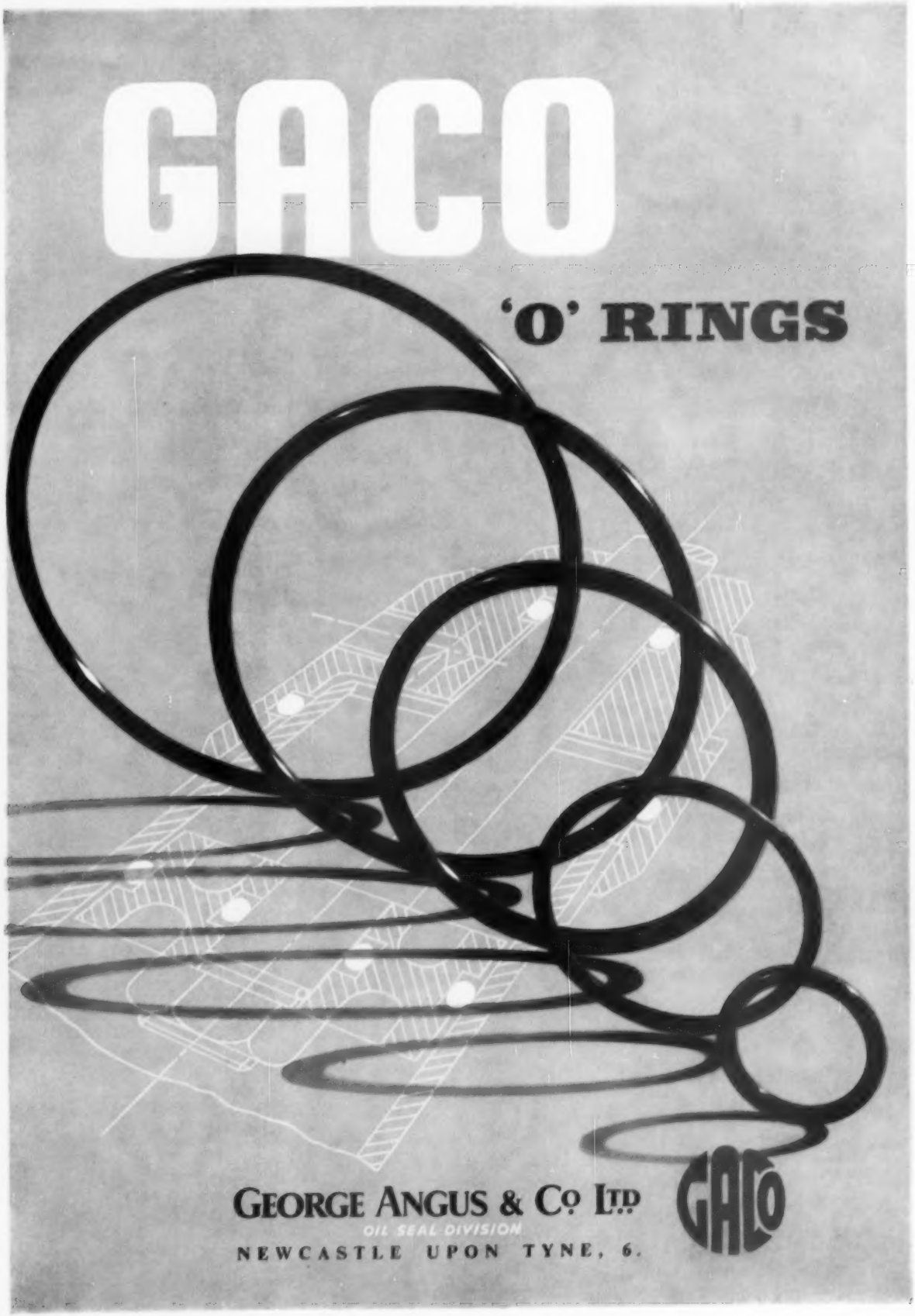
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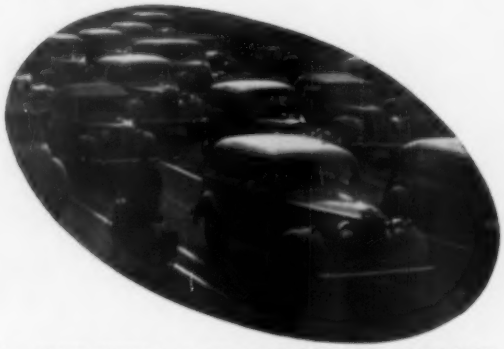

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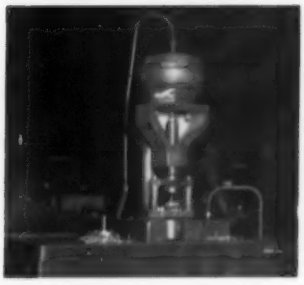

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DESIGN MATERIALS **AUTOMOBILE ENGINEER** PRODUCTION METHODS WORKS EQUIPMENT

Light Commercial Vehicles

FOR some years now throughout Western Europe there has been a continually expanding market for light commercial vehicles. A survey of those exhibited at the Brussels Show disclosed that in many cases Continental manufacturers are producing several different types of vehicles with as many common components as possible. To achieve this, the makers are tending to concentrate on the development of special light commercial vehicle chassis instead of modifying private car models. There is much to be said in favour of this policy. For instance, when a light commercial vehicle body is mounted on a passenger car chassis, it is usually difficult to obtain a satisfactory weight distribution, and in addition the suspension characteristics tend to be unsuitable. To set off against these drawbacks, there is, of course, the possibility that the front wings, bonnet, scuttle and dash may be common to both the commercial vehicle and the private car.

One of the most popular of the Continental developments is commonly known as a kombi wagon. This has a van body with large windows in the sides and the rear and has seats that can be removed, as in a Countryman saloon, to provide more space for the carriage of goods. In this type of design, the emphasis is placed on suitability for commercial rather than passenger transport.

Another type of vehicle that is becoming increasingly popular on the Contenent is the small bus, capable of accommodating from six to fourteen seated passengers. These vehicles are used by hotels for carrying small parties to and from the station. The demand is not great enough to warrant the production of a special vehicle solely for this application, but models based on light van designs can be produced at reasonable prices.

Vehicle Range

With a range comprising a van, kombi, light bus, ambulance and pick-up, production of the basic components can be undertaken in quantities large enough to warrant the necessary tooling. In this range, almost all the body components are common, except to the pick-up. A special effort is being made to bring pick-up designs closer into line with the others, but opinions still differ as to what measures should be taken. One manufacturer offers an open-sided van, which has no panelling between the waist and the cant rail, the roof being supported on pillars. Others arrange the front end of the basic body in such a manner that only a rear panel has to be added to form a cab suitable for a pick-up. Yet another practice is simply to style the pick-up in such a way that its panels can be fitted to the basic structure of the van with the minimum of modification.

Up to the present, the styling of all these designs has been based on what is currently accepted as suitable for vans. Development, however, is still at an early stage and it is probable that, because of the application of these types to passenger transport, the greatest demand in the future will be for those with the most attractive appearance. That it is possible to make a vehicle of this type as attractive as a private car has been demonstrated by British manufacturers, one at least for over three years, has had in production a range of light commercial vehicles based on a separate chassis frame, but with the engine, gearbox and many other mechanical components common to both private cars and commercial vehicles.

Floor height

For a design to be applicable to as wide a range of vehicles as possible, it is essential that the floor height should be low. This appears to suggest that chassisless construction should be adopted. However, unless it is acceptable for the sill to be on top of the floor, a feature that is not generally regarded as practicable for commercial vehicles, the gain so far as floor height is concerned is negligible. The use of a separate frame is preferable, since it makes it much easier to adapt the vehicle to the pick-up design. However, because of the restriction on floor height for the other types, it is scarcely practicable to incorporate a frame that will be adequate without a degree of support from the body. This implies that in the pick-up there must be sound connection between the body and cab. Another measure that is being adopted to reduce the height of the floor above the ground is the abandonment of the traditional position of the petrol tank between the frame side members at the rear; now the tank more often than not is installed above the floor.

Continental manufacturers obviously consider that the market for light commercial vehicles will continue to expand. The market is already highly competitive; therefore it is only to be expected that the tendency to employ specially designed vehicles rather than to adapt passenger car chassis will become even more marked.

This 14-seater coach, by Desot, is mounted on the Renault 1,400 kg chassis and incorporates many of the standard panels of the van

Brussels Show

Features of Technical Interest, With Special Reference to Continental Light Commercial Vehicles

The Renault 1,000 kg van can be supplied with or without a sliding door on the side of the body

A number of positive trends of design were discernible at the 1956 Brussels Show. It was particularly noticeable that an increasing number of American, heavy commercial vehicles have the wrap-round type of windscreen that has become so popular on cars. Wrap-round rear lights also are employed in a number of designs. These features give such a marked improvement, so far as range of vision is concerned, that they are bound to be even more widely adopted. Most manufacturers have devoted considerable effort towards weight reduction. For passenger-carrying and light commercial vehicles, there is a tendency to employ exceptionally light frames, to carry the mechanical components, and to rely on the bodies for giving adequate strength and stiffness to take the operational loads. In all types of vehicles, increasing attention is being devoted to details, with a view to reducing weight. For example, many structural components, both of frames and cabs, have lightening holes punched in them. In some instances, relatively light frames are employed for heavy commercial vehicles; they are reinforced locally at points where loading is severe. It is possible to use a light frame for one model, and to reinforce it locally when it is used as the basis for a heavier vehicle. Although this saves tooling costs, the labour involved in fitting the reinforcement must also be taken into consideration.

Low prime cost is now the dominant factor, so far as sales are concerned in Belgium. Many manufacturers have followed the British lead in rationalization to reduce costs. This trend is most noticeable in light commercial vehicles. Considerable effort has been directed towards making as many body components as possible common to a wide range of vehicles, not only of the same carrying capacity, but also with completely different chassis and bodies and with capacities varying as much as from one to two-and-a-half tons.

Renault and Citroën

The Renault commercial vehicle range is a particularly good example of rationalization of bodywork by a Continental manufacturer. In their vehicles with load-carrying capacities of 1,000 kg, 1,400 kg and 2,500 kg, most of the cab components are common to the whole range. This is particularly noteworthy, since the rear ends of the cabs of the 2,500 kg vehicles are 70 in wide at the waist, as against a width of 67in for the 1,000 kg types. The panels are almost all of simple form so tooling costs undoubtedly are low. In all the vehicles the width of the front panel at the waist is 53in. The only components that are not common are the roof, floor and back panels of the cabs.

Among their other exhibits were one van of conventional form and one without side panelling between the waist and the roof; each has a load-carrying capacity of 1,000 kg. The open-sided van might almost be described as a hard-top pick-up body. It has a tailboard at the rear, while the roof is supported by the cab at the front, the quarter panels at the rear and by two intermediate pillars on each side. This type of vehicle is used as a travelling shop, for example, by greengrocers who take their goods from door-to-door and who therefore need to display them on racks in such a way that they are readily accessible from outside the vehicle.

The general form and style of the front end can be seen from the accompanying illustrations. An interesting feature

The rear panel of the Renault van on the 2,500 kg chassis is fabricated from two parts

An interesting feature of the Renault commercial vehicles is that the cabs are flash butt-welded to the rear portions of their bodies

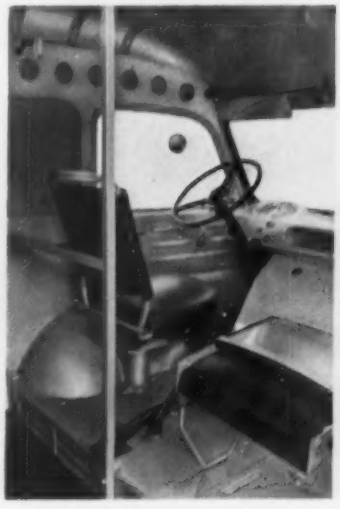
of the design is that the side panels of the cab are flash butt-welded to the body. Above the waist of the open-sided van, the side panel of the cab is lapped over a vertical pillar and spot welded to it. This pillar extends between the cant rail and the floor, and is of top hat section, with a closing plate spot welded to its flanges. When the cab only is fitted on the chassis, and a separate body is mounted behind it, a rear panel assembly is fitted to close the back of the cab. This panel is fabricated from two pressings joined together vertically at the centre. All except the lower edges of the two panels have rearward extending flanges. Thus, the vertical joint at the centre is formed by spot welding together the flanges of adjacent panels. The whole assembly is inserted into the aperture at the back of the cab; the flanges are then spot welded to the side and roof panels. The lower edge is spot welded to a cross member forming the rear edge of the floor. It is not clear why this panel should be made in two pieces, but possibly it is because of a policy of rationalization with regard to widths of sheet steel employed. The design is obviously intended for relatively large-scale production in which jigging plays an important part.

The roof panel also is a fabricated component. It is formed in three pieces, one over the cab and the other two, of approximately equal lengths, over the rear portion of the vehicle. The panels are stiffened by transverse flutes, or channel sections, pressed in. In the vans, the joints between the panels are of the spot welded, lap type and each is formed in the base of one of transverse flutes. An unusual feature of the design is that the edges of the roof are flanged to form a section like an inverted drip channel. A proper drip channel is fitted only over the leading and top edges of the door opening.

Another interesting feature of the design of the plain and open-sided versions of the van is that their rear end panelling is almost identical. The rear quarter panels of both have vertical pillars spot welded to their forward edges and also on each side of the rear door opening. The forward edges are flash butt-welded to the body sides, in the same way as are the rear edges of the cab side panels. Although the rear door opening is identical on both types of vehicle, in the open-sided version a tailboard is fitted instead of the double doors of the van. A simple fastener secures the tailboard in the closed position. It comprises a slotted plate on each side of the tailboard which, as the tailboard is raised, just clears a lever and its pivot on the rear face of the pillar. It is locked by swinging the lever about its pivot so that it is no longer in line with the slot in the plate. A ramp is formed on the rear of the plate so that as the lever is rotated, the clearance between it and the plate is taken up and the tailboard cannot rattle. Among the other components that are common to the whole range are the wings. Therefore, on the smaller vehicles, there is a relatively large clearance between the wheels and the wings.

A sliding door can be fitted to the van as an optional extra. It is a flat rectangular panel with a rectangular, top hat section frame to reinforce its edges, and a single horizontal rail, also of top hat section, at the waist. The whole assembly

Left, in the Renault van, the passenger's seat folds up over the wheel arch
Right, flash butt-welds join the rear end and body sides of this Renault van



is only $\frac{3}{4}$in thick. Spot welding, at a pitch of about 12 in, is employed to attach the top hat section reinforcement frame to the outer panel. The waist rail is joined to the frame by a T-shaped gusset plate at each end. The corners of the frame are mitred and L-shaped gussets are spot welded on to form the junction.

A simple frame is spot welded to the side panel of the body to carry the runners and seals for the door. The track on which the door slides is not parallel to the side of the body, but is arranged so that the door moves slightly outwards to clear the body sides as it is moved to the rear. A flanged, V-section metal strip is spot-welded to the lower edge of the door frame and it seats on a rubber strip on the sill when the door is closed. The front edge of the door is bent inwards through 180 deg round the flange of the top hat section stiffener. This edge seats on a rubber strip on the front pillar. The rear edge of the door panel is flanged inwards at 90 deg and carries a rubber strip which trails over the body panel to form the seal. A rubber skirting strip is attached to the top horizontal portion of the opening to seal on the door.

The interior equipment of all the cabs is practically identical, but in the vans the passenger's seat is different from that in the cabs of the $2\frac{1}{2}$ tonne vehicles. In the vans, the passenger's seat squab can be folded down and the whole assembly is hinged so that it can be folded up over the wheel arch to give access to the rear compartment and also to give extra space if necessary to stow exceptionally long loads. The driver's seat is mounted on a platform on top of a pedestal and is adjustable in the fore and aft directions. A simple dash facia is employed. The instrument panel is secured to it by four screws, and two cubby holes are incorporated to the right of the steering column.

A fourteen-seater coach, by Desot, was exhibited on the 1,400 kg chassis. Again, many of the body panels are identical with those of the other commercial vehicles. The front end incorporates most of the standard cab panels and the rear body work is similar to the open-sided van. The front doors and all the wheel arches are standard components, but an extra door is incorporated on the near side at the rear. In addition to the windows on each door, there are two large windows on each side. A large rectangular, transparent ventilating-panel is fitted in the roof. This panel is mounted on swinging links so that when it is opened it is elevated parallel to the roof. Each rear spring is reinforced by the addition of another semi-elliptic spring below it. The vertical clearances between the ends of the pairs of springs are filled by rubber pads.

Citroën showed their well known range of commercial vehicles. Among these are a shooting brake and a van version of the 2CV model, on which a van body has been attached immediately behind the front door hinge-pillar. The front ends of these models are identical to that of the car, and the rear portions of the bodies are the same for both the van and the shooting brake, except that in the latter a large window is fitted on each side. All the panels of the rear portion are flat or curved in two dimensions only, and are fluted, as are most of the panels employed by Citroën in all their commercial vehicles. Although, so far as external dimensions are concerned, the rear portion is wider than that of the car, the space available for the rear seats is only slightly greater than in the car version, because of the restriction imposed by the wheel arches. However, the spare wheel is stowed immediately in front of the wheel arch on one side, and the petrol tank is housed in the corresponding position on the other side. Access to both can be gained by removing an exterior panel. The object in placing the tank and spare wheel in this position, of course, is to lower the floor at the rear, and thus make more space available for the load. Double doors are fitted in the rear end of this body.

Since this is a two-door model, and the front door is relatively small, special measures have had to be taken to give access to the rear seats. All the seats are on tubular frames. On each side of the passenger's seat the longitudinal rail that forms its base rests in a channel section link which lies, flanges uppermost, on the floor. One end of this link is pinned to the rail and the other is pivoted between a pair of lugs on the floor. When the seat is in its normal position,

Above: the passenger's seat in the front of the Citroen 2CV van and 'Weekend' models can be moved forward on short links to give access to the rear.

Left: the rear portion of the commercial vehicle body on the Citroen 2CV is wider than the car body, and the petrol tank and spare wheel are carried forward of the rear wheels to enable the floor height to be reduced.

Right: wrap-round windscreens are employed on the G.M.C. trucks. Particular care has to be taken in this type of design to avoid breakage of the glass due to body distortion in operation over rough terrain

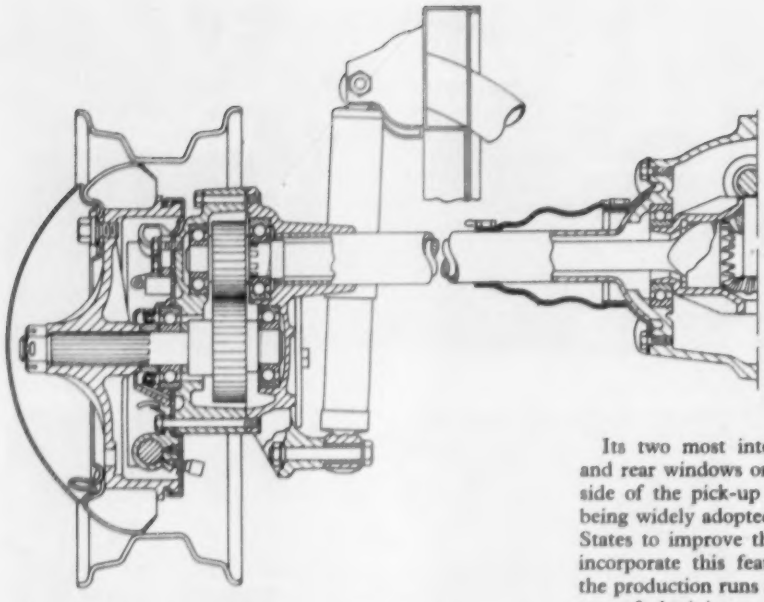
Above: flat glass panels are employed in the windscreen of this D.A.F. truck, and separate, rear quarter lights are incorporated

Right: on each side of this Chevrolet pick-up body, a plastics panel is fitted for styling purposes

Left: this pick-up body on a Fiat 1100 chassis is remarkable for the number of small panels used in its construction

Below: a folding tilt is employed on the Simca pick-up

Left: the tooling costs for the production of the Simca pick-up undoubtedly are low



A reduction gear is incorporated at each end of the rear axle of the Volkswagen commercial vehicles so that the standard gearbox and final drive assembly can be used.

a short peg extending inwards from the forward end of the base rail registers in a horizontal slot in the forward edge of the inner lug on the floor. To move the seat to give access to the rear, it is necessary to push it forwards and at the same time lift the squab. The initial forward motion disengages the pegs from the slots, and the whole assembly then swings forwards and upwards on its link, as shown in an accompanying illustration.

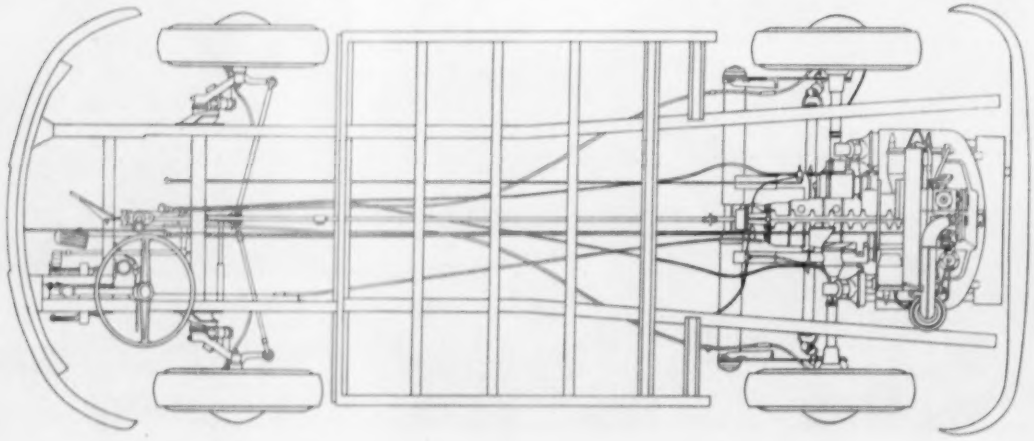
Pick-ups

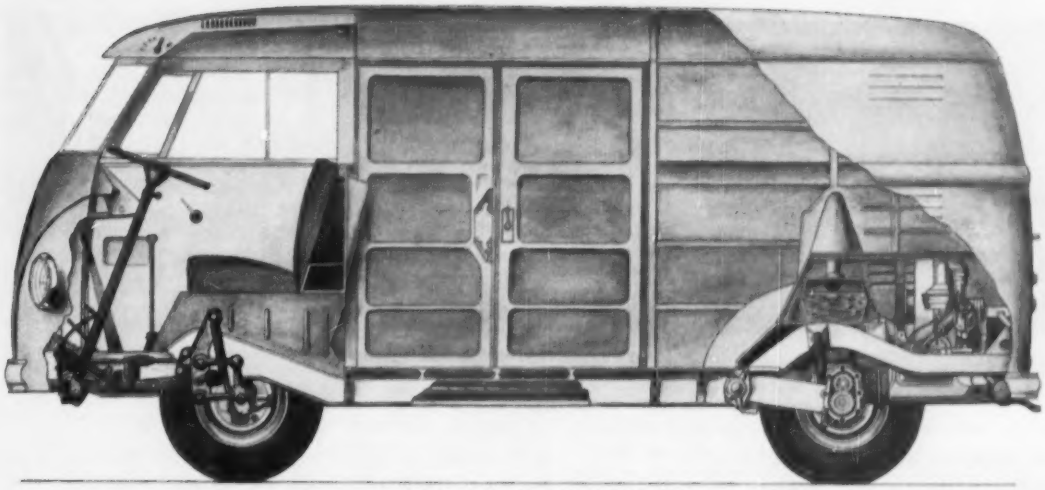
The pick-up is probably the most difficult of all types of body to design, not only so far as the stylist is concerned, but also because of the structural problems that it sets. This is borne out by the number of different approaches to the design of this type of vehicle. The Chevrolet Cameo Carrier, Series 3100 pick-up was shown largely for display purposes at Brussels, but it is in series production for sale in the United States. It is powered by a 147 b.h.p. V-8 engine and incorporates the four-speed Hydramatic transmission. The vehicle is exceptionally large for this type of application. Its dry weight is about 5,000 lb and its carrying capacity is half a ton. This is not much for such a large vehicle.

Its two most interesting features are wrap-round front and rear windows on the cab and plastics panelling on each side of the pick-up body. The wrap-round windscreen is being widely adopted for commercial vehicles in the United States to improve the range of vision. G.M.C. trucks also incorporate this feature, which inevitably is costly unless the production runs are on a large scale. A much less costly way of obtaining a similar effect is to use a number of flat panels, as on the D.A.F. truck, illustrated alongside the G.M.C. truck and the Chevrolet pick-up. This device, of course, is used by several British manufacturers. In view of the rough usage that heavy commercial vehicles have to withstand, many authorities do not favour wrap-round screens because of the danger of the glass breaking. They prefer instead to incorporate stiff pillars to divide screens of this form into three or even four pieces.

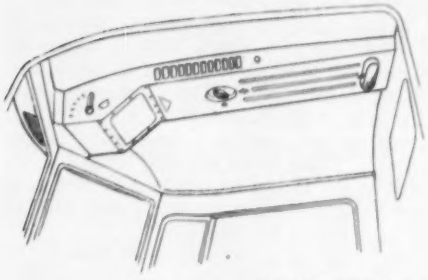
In the pick-up body, a conventional rectangular container with a hinged tailboard at the rear is employed. Only two plastics panels are added, one on each side, and they are only for styling purposes. A chromium plated strip at the front edge of each acts as a finisher between it and the cab. By employing plastics panels in this way, a pleasing appearance can be obtained with a minimum of tooling. Moreover, plastics panels are less liable to damage when goods are being loaded or unloaded over the sides of the vehicle. Although plastics bodywork is expensive to produce, because of the labour involved, there is much to be said for its employment in this type of application, particularly when the number of panels is kept to a minimum, as it is in the Cameo Carrier. It is the sort of device that might appeal to

A simple underframe is used for the Volkswagen rear-engined commercial vehicles, which are offered with or without a double door in the side

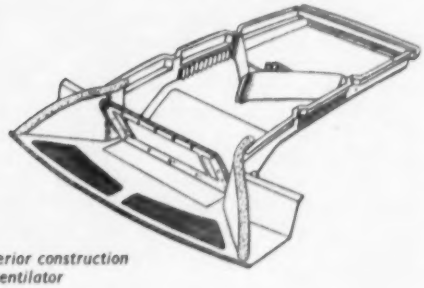




The top of the engine compartment has been lowered in the latest versions of the Volkswagen vehicles



Ventilator under the cab roof of the Volkswagen



Details of the interior construction of the ventilator

small manufacturers who modify standard bodies to suit customers who require vehicles for special purposes.

Fiat 1100 pick-up

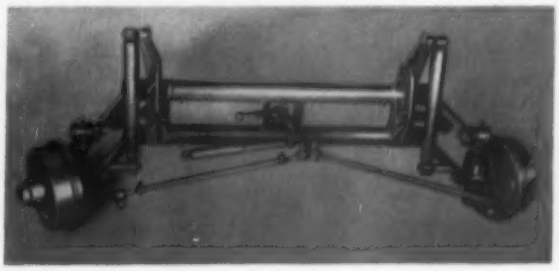
The front end of the Fiat 1100 pick-up is similar to that of the car, but to accommodate larger wheels, separate wings are fitted, and two-piece side panels are fitted below the horizontal joints that extend back from the lamp apertures to the door pillars. The vertical joints between these two pieces are above the wheel centres. Thus the bonnet surround and front panel, and the doors are identical to those of the private car. An unusual feature of the design is the way in which the body panelling is fabricated from relatively small parts. The reason for this is not clear, but possibly scraps of sheet steel left over during the manufacture of larger components are employed. At first sight it would appear that fabrication costs would be high, but this might not be so if multiple-head spot welding machines and adequate jigging were to be employed to facilitate manufacture.

A small sill outer panel is fitted and the panneling of the rear end of the body is divided horizontally at the level of the lower hinge of the door. Thus, the pick-up body behind the cab. comprises the two side panels, and the tailboard, with separate skirt panels in front of and behind the rear wheels and also below the tailboard.

The side panels extend from the door hinge pillar at the back of the cab, round the rear quarter of the pick-up body, to the pillars on each side of the tailboard. Their upper edges are flanged inwards and turned down to form an inverted channel section. They are supported by a framework comprising three vertical and three horizontal channel sections welded between their edges and the floor. This framework also serves to protect the body panelling from damage by the load.

A two piece panel forms the rear of the cab. One piece extends from the floor to a horizontal joint several inches above the waist, and the upper piece terminates below the drip channel. The rear quarter panels are also separate components, which wrap round the back panel for a distance of about 1½in to form a lap joint. Nearly all the joints are formed by spot welding together right angle flanges on the panel edges. This type of joint is also used between the base of each quarter panel and the upper edge at the front end of the body side panel, but, in addition, there is a small amount of flame welding in the angle between the rear edge of the rear quarter panel and the upper edge of the pick-up body. Horizontal flutes are pressed into the lower portion of the rear panel of the cab, and three top hat sections are spot welded vertically to the rear face of the panel to protect it against damage. The spot welds join the flanges of the top

Front suspension and steering assembly of the Volkswagen commercial vehicles. A steering damper is incorporated



Details of the Volkswagen ambulance. Left: view from the rear showing one of the stretchers folded and stowed against the right-hand side of the vehicle. Centre: view through the side door showing the invalid's chair with handles extended. Right: mounting for the swivel-lamp and rear view mirror. Below: Dash and controls

hat sections to the bases of the flutes. A timber floor is employed in the body of the pick-up.

Simca Aronde pick-up

An interesting pick-up body is built on the Simca Aronde chassis. It is called the Intendante model. The whole of the front end, up to the door shut pillar, as well as the floor, heelboard and rear seat pan, and possibly the rear floor structure, are the same as in the private car model. The rear panel of the cab is divided horizontally at the waist, and the horizontal joint between the two components is formed by spot welding together right angle flanges on their adjacent edges. Both the upper and lower portions have horizontal flutes pressed in them, and the assembly is flanged all round its edges. All the flanges are turned to the rear so that spot welding, to join them to the sides and roof, can be done from outside the vehicle, but the top and side edges are pressed locally to form a channel section, so that the trailing edges of their flanges are in line with the plane of the panel. This arrangement has been adopted so that a 1in thick timber board can be bolted flat against the rear face of the cab. The lower edge of the rear panel is turned back and attached to the pick-up body floor. A filler panel between the rear seat pan and this floor completes the front part of the structure.

An unusual feature is that the tilt cover, with its hoop sticks, folds up against the board bolted to the back of the cab. The front end of this cover is tacked to the board, and its lower edge is secured by press-stud type fasteners to the top rail of the pick-up body. At the back, it extends about 7in inboard of each rear corner of the body.

There are three hoop sticks. The front one is more or less vertical and its lower ends are hinged to the front ends of angle sections, welded along the upper edges of the pick-up body. Pivoted to the other ends of these angle sections is the rear hoop stick; each side of which is cranked, as can be seen from the accompanying illustration. The intermediate hoop stick is pivoted to lugs on the inclined arms of the rear one. All the hoop sticks are tied together by two straps, one on each side of the top. These straps are each secured at the front to the board on the back of the cab, and at the rear to an eye on the upper edge of the rear end of the body, adjacent to the pillars on each side of the tailboard.

As can be seen from the accompanying illustration, all the body panels, except, of course, those that are also used in the private car, are either flat or curved in two dimensions only. Therefore, the tooling costs undoubtedly are low. The body sides are fluted horizontally and the corners are joined by angle sections applied externally. Top hat section, vertical stiffeners are spot welded to the sides and ends. Spot welds attach the flanges of these sections to the bases of the flutes, which are pressed into the panels at about 4½in pitch. There are three vertical top hat sections on each side and on the tailboard, while on the rear panel of the cab there are only two. The upper edges of the pick-up body are flanged inwards and turned down to form an inverted channel section in which an angle section reinforcement is spot welded. A metal floor is employed. It is protected by timber battens.

Volkswagen

Volkswagen have recently made a number of modifications to their vans. The telescopic shock absorbers have been redesigned, and now have a stroke of 130 mm. Laminated torsion bars of completely different design are fitted in the front suspension of the latest models. The earlier ones had torsion bars comprising four rectangular section leaves which, when assembled together, had an overall cross sectional dimension of 22½ mm deep × 31 mm wide. Now, the torsion bars are still 31 mm wide, but are 28·4 mm deep and have nine leaves. These leaves, like the earlier ones, are all of equal thickness but have rounded edges instead of chamfered ones and, of course, are of thinner rectangular section. The centre three leaves are the full width of the spring cross section, the next two above and below them are of slightly smaller width and the top and bottom leaves are still smaller. Thus, the cross section of the whole assembly now approximates to a circle instead of a rectangle.

The two cross tubes, that house the torsion bar springs are connected together by a bracket at each end, and the

whole assembly is termed the front axle. Each bracket is flanged to receive four bolts, by means of which the front axle and suspension assembly is secured to the vehicle structure, and has an upward extension that carries the upper end of the shock absorber. This layout is convenient for both assembly and servicing. Alignment is obtained by fitting shims between the flanges and the structure. The end bracket on each side also carries a single stop extending between the two trailing arms. This stop serves for both the bump and rebound limits. Needless to say, the arm that supports it has to be particularly robust because of the leverage that the wheels and suspension links can apply to it.

Another change is in the steering linkage. Equal length rods, of the two-piece track rod system, are now connected to a bell crank lever pivoted on the centre of the lower of the two cross tubes of the front axle. The steering levers on the wheel assemblies are lower than before. Adjacent to the track rod connections, a telescopic hydraulic damper is attached to the arm of the central bell crank lever; its other other end is secured to the vehicle structure. The other end of the bell crank lever is, of course, connected to the drop arm of the steering box. Because of the changed position of the box, the lead of the cam is now in the opposite direction to what it was before. To improve the driver's range of vision over the instruments, the three-spoke steering wheel has been replaced by a two-spoke one, So that the assembly can be bolted up without straining the facia, a means of adjustment is provided at the attachment of the upper end of the column.

At the rear, a double-reduction axle is still employed. The second reduction is by a pair of helical spur gears at each outer end of the axle. This arrangement has been adopted so that the standard gearbox, final drive and engine assembly can be employed. The suspension system is much the same as before, but the spring plates, which form the trailing links and connect the rear wheels with the torsion bars, are each attached directly by four bolts to the reduction gear case at the end of the axle, instead of to the axle tubes. Thus, they are now closer to the wheels. This arrangement has been adopted to obtain a better disposition of the bolts, which are now less heavily stressed. The lever arm type shock absorbers have been replaced by light-weight, telescopic units. They are the same size as those on the front axle, but have different characteristics. The lower end of each is attached to the reduction gear case and the top end to a bracket on the frame side member. It is stated by the manufacturers that these telescopic shock absorbers are more durable than the lever arm type previously employed. The vehicle is now equipped with 6.40—15 tyres and the inflation pressures are reduced to 28 lb/in² at the front and 33lb/in² at the rear. Wheel discs with 4½K × 15 rims are employed and are slotted to assist brake cooling.

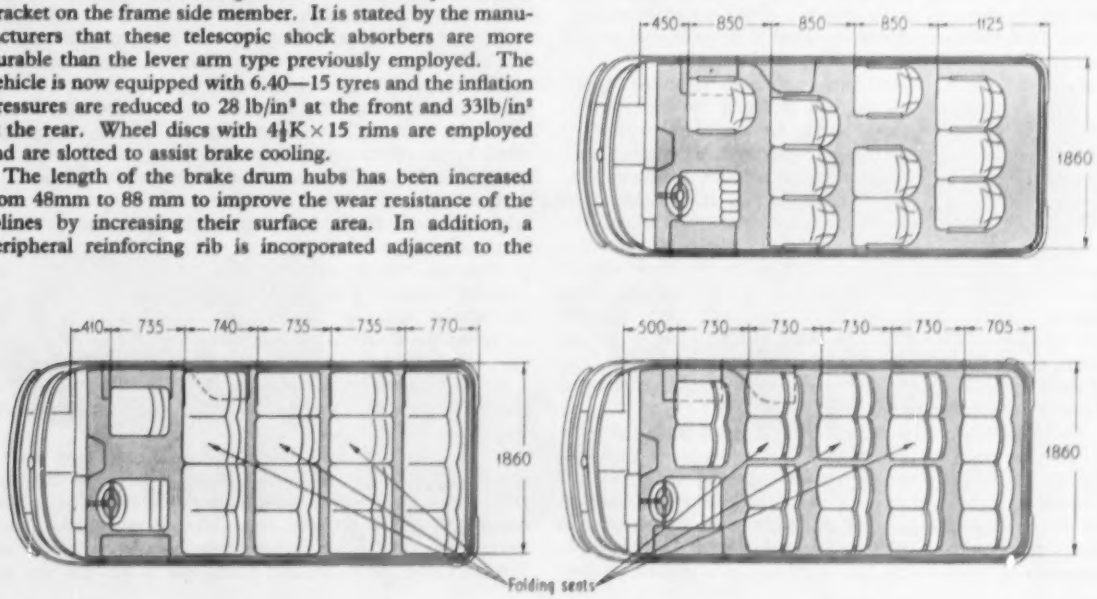
The length of the brake drum hubs has been increased from 48mm to 88 mm to improve the wear resistance of the splines by increasing their surface area. In addition, a peripheral reinforcing rib is incorporated adjacent to the edge of the flange of the brake drum, both to stiffen the drum and to increase the rate of cooling. The two leading shoe type of brake layout has been incorporated at the front and the shoe width has been increased from 40 mm to 50 mm. At the rear, the brake shoes are the same width as before, that is, 40 mm. Thus, the total lining area is 836 cm² (130 in²) instead of 700 cm² (109 in²).

Another alteration is to the thickness of the shoe linings, which has been increased from 4 mm to 5 mm to give a longer service life. Visual inspection through the adjusting hole in the brake drum shows the amount of wear that has taken place. The linings should be replaced when they have worn down to a thickness of about 2.5 mm. To obtain the most effective distribution of braking force between the front and rear brakes, the tensions of the shoe return springs have been modified. The rear brakes incorporate conventional return springs for the hand brake cables.

Both the master and the wheel cylinders are of larger volume and the pressures in the system are decreased: this adds to the reliability of the system. The wheel cylinders and brake shoe anchorages are bolted to the steering knuckles at the front and to the reduction gear case covers at the rear. Therefore, the back plates, which now only serve to protect the brakes from water and other foreign matter and to guide the brake shoes, are of lighter construction.

The engine compartment, which of course is at the back, has been reduced in height by 11.8 in, and a single rear door, hinged at its upper edge, is now employed to give access for loading from the rear. When the lid is lifted, the opening disclosed is 35.4in wide × 28.5in deep. The reduction in height has been obtained by installing the oil bath air cleaner at the side of the engine and connecting it to the carburettor by an inverted U-shaped duct, whereas before it was above the carburettor. The petrol tank is now immediately above the rear axle, instead of behind the engine: this improves the accessibility of the power unit. On the earlier models, the spare wheel was stowed above the engine compartment, but it is now carried between the seat squab and the bulkhead separating the driver's and loading compartments. This

Alternative seating plans for the Mercedes Benz light-weight bus. The measurements are in metric dimensions



Three-wheeled pick-ups, such as this Goliath model, are popular on the Continent

bulkhead is dished locally to receive the upper portion of the wheel and thus to allow for the slope of the seat squab. The seat is of the bench type, with its squab hinged at its upper edge to give access to the spare wheel. Its cushion has been increased in thickness from 5.5in to 7.5in. The depth of the windscreen has been increased by raising the headrail ½in. This, together with the greater deflection of the seat cushion, gives an improved range of vision. The windscreen is of toughened glass and is of the type in which a portion of the panel in front of the driver remains clear if the remainder is struck by a stone and crazed.

A noteworthy feature of this range of vehicles is the effectiveness of its ventilation system. The air intake is underneath a forward projection of the canopy above the windscreen. Owing to the flow characteristics of the air over the vehicle, the air pressure in this position is relatively high. Wire gauzes fit over the intakes to prevent the entry of insects. A longitudinal duct is attached to the canopy immediately behind the intake. A flap, pivoted at its lower edge, is installed near the front end of this duct so that the in-flow of air can be stopped completely or regulated to any required degree. Behind this flap, there are louvres in the side of the duct to allow the air to pass into the driver's compartment. There is another outlet at the extreme rear end of the duct through which the air can pass into the rear compartment of the vehicle. All three of these outlets are arranged so that the air is directed along the undersurface of the roof panel so as not to cause a draught that would cause discomfort to the occupants.

A second control, in the form of a centrally-pivoted lever, is fitted in the base of the duct between the louvres that supply air to the driver's compartment. This control is connected by two tie rods inside the duct to a deflector plate on each side of it. The trailing edge of each deflector plate is hinged about a vertical axis at the rear end of the set of louvres in the side of the duct. These deflectors extend the full length of the louvres on each side. When the control is moved to one extreme of its travel it forces the plates against the louvres to close them, so that all the incoming air goes into the rear compartment; at the other extreme, it draws the forward edges of the deflector plates together at the centre of the duct, so that all the incoming air goes into the driver's compartment. Any intermediate position between these two extremes can also be selected.

Air outlet louvres are incorporated in the sides of the body at the rear end of the vehicle. The provision of through-ventilation is important for certain types of operation, for instance, in vans used to carry bread, otherwise condensation on the metal components of the body tends to cause rapid deterioration. Also, with rear-engined vehicles, it is probably necessary to ensure that the ventilation is adequate to keep the interior of the body cool. A fan can be fitted in the ventilation duct at the front of the vehicle if necessary.

For operation in cold weather, heating for the interior is effected by employing the air that has been warmed by its passage over the engine cylinders. In the vans, a circular section duct carries this air to the front of the vehicle, where it enters a vertical pipe between the toeboard and dash. This pipe delivers air to the two demister ducts; it also has two ports, one on each side, near its base, to allow the air to pass out near the feet of the occupants in the driver's compartment. These ports are controlled by a simple sleeve valve, on which is a handle so that it can be rotated manually. In the Micro Bus, station wagon and ambulance versions of this vehicle, additional outlets are incorporated to direct the air into the rear compartment.

The vans can be supplied with double doors either on one side only or on both sides, immediately behind the driver's compartment. These doors are now equipped with handles so that the square-section key, previously needed to open them, is no longer required. The handles are in recesses so that they do not project far enough to be damaged. Stiff inner panels have been incorporated to offset any tendency for rattles to develop after long periods of service.

Provision of such large cut-outs in the side of the vehicle must have set the designers some difficult problems with regard to stiffness and strength. To provide the necessary reinforcement, the under-frame is stiffened locally by the addition of two side members outboard of the main side members of the frame. These side members extend extend between the front and rear wheel boxes. They are supported on five cross members extending the full width of the vehicle and two short cross members, immediately in front of the rear wheel boxes, extending between the additional side members and the main ones. Because of the incorporation of a modified front axle is has been possible to change the shape of the main side members to increase their strength and stiffness. Previously, there was a large arch in the side members, where they passed over the axle, but in the latest models this arch is much smaller. This form of underframe is the basis for the whole range of Volkswagen vehicles of this type, including the delivery van, station wagon, or *Kombi*, Micro bus, Micro Bus de luxe and ambulance. The pick-up is of a different type of construction and has drop sides. Its loading platform is at the level of the top of the engine compartment.

In the delivery van and station wagon, the loading space is approximately 8ft 10.3in long × 4ft 11in wide × 4ft 5in high, giving a capacity of approximately 162 ft³. The seating capacities of the vehicles are: delivery van, pick-up and station wagon, 3 in the driver's cab; ambulance 7, of which 3 are in the driver's cab; and Micro Bus 8. On the rear axle

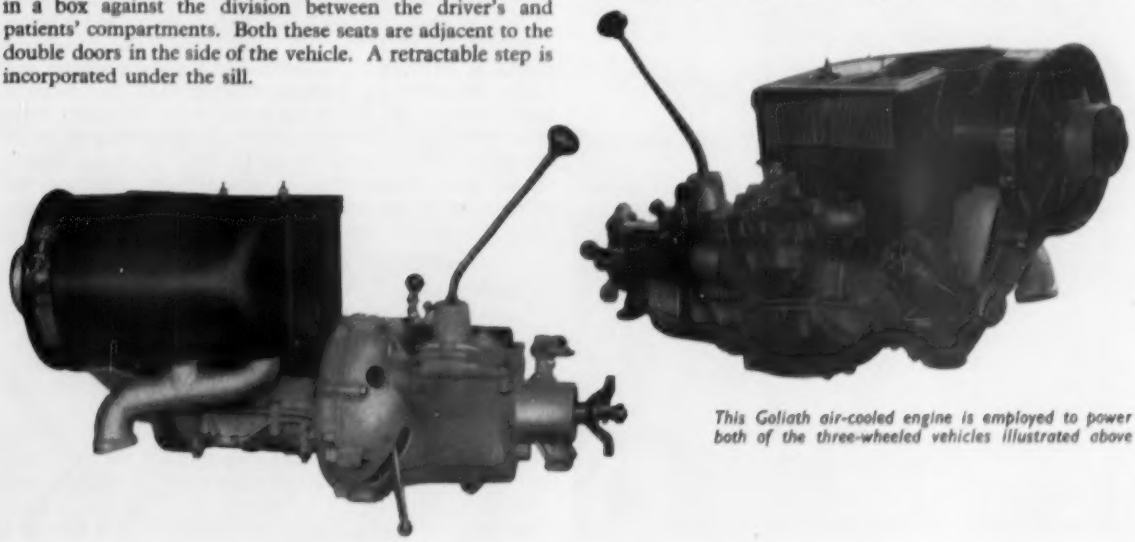
The Goliath Goli van has a door in the side

the maximum permissible load is 2,200 lb and on the front axle it is 2,090 lb. The overall dimensions of these vehicles are as follows. In length, they are all 13ft 9in except the Micro Bus, which is 1in longer. They vary in width from 5ft 7in to 5ft 9in and, except for the pick-up, their heights are all 6ft 4.4in. The weights are given in the accompanying table.

The most recent addition to the range of Volkswagen commercial vehicles is the ambulance. Its most noteworthy feature is the amount of equipment that has been accommodated in such a small vehicle. All the equipment is of light-weight, so as to maintain a maximum capacity for carrying patients and attendants. There are two stretchers on a platform extending the full width of the vehicle above the wheel boxes. The rear door is hinged at its lower edge and, when open, is retained at an angle a few degrees below the horizontal, so that when the stretcher is withdrawn by an attendant at one end, the other end can be rested on it while the second attendant gets into position. There are guide rails on the platform and the stretchers are fitted with castors that run in these rails, which locate them. One of the stretchers can be folded double and strapped against the side of the vehicle. When it is in this position, a squab of a seat, which is accommodated under the head of the stretcher when it is in the extended position, can be folded up for an attendant. When both stretchers are in use, the attendant uses a small folding seat, which when not in use is stowed vertically in a box against the division between the driver's and patients' compartments. Both these seats are adjacent to the double doors in the side of the vehicle. A retractable step is incorporated under the sill.

On the side opposite these double doors, a third seat is installed, but this is more elaborate and is a special invalid's chair. It is equipped with head and arm reats and an adjustable squab so that the invalid can be accommodated almost in a lying position if necessary. Telescopic handles, like stretcher handles, can be pulled out at the front and rear so that two attendants can carry the seat with the patient in it. Guide channels are incorporated in the floor of the ambulance so that the chair can be slid straight out of the side doors. The invalid chair, because of its shorter length, can be manoeuvred down twisting staircases much more easily than a stretcher. Under the stretcher platforms there are cupboards for dressings and medical supplies. One of these cupboards has a lock and key so that dangerous drugs can be kept out of reach of the patients. Special equipment, such as oxygen apparatus, of course, can be carried in place of the invalid chair. In this vehicle, the ventilation system is the same as in the vans, except that a fan is incorporated in the duct to ensure that the patients' compartment is adequately ventilated, even when the ambulance is stationary.

An interesting detail feature of the ambulance is the common mounting for a swivel lamp and the rear-view mirror. As can be seen from the accompanying illustration, the mirror is mounted on the back of the lamp and both can be reached easily by the driver when his window is open. By mounting these two components together, it is only necessary to use one stay to carry them instead of two.



This Goliath air-cooled engine is employed to power both of the three-wheeled vehicles illustrated above

Further simplification has been effected by using the lower end of the stay as a hinge pin for the door.

Mercedes Benz

Three new models, based on a 1¾ tonne chassis, have recently been introduced by Mercedes Benz: they are a delivery van, a pick-up and a 17-seater bus. All three models are powered by the 1.8 litre, four-cylinder diesel engine produced by the same manufacturer. This engine, which has been in use for some years in passenger cars, now develops 43 b.h.p. DIN or 46 b.h.p. by the S.A.E. rating method. Previously it developed 40 b.h.p. DIN. The manufacturers state that they have reduced appreciably the combustion noise and have improved the brake specific fuel consumption. These advances are said to be the result of incorporating a centrifugal governor to vary the injection timing with engine speed. The specification of the engine, which is designated the OM 636 VII, is as follows. Its bore and stroke are 75 mm and 100 mm respectively and the swept volume is 1,767 cm³. The maximum output of 43 b.h.p. is developed at 3,500 r.p.m. and the maximum torque is 74.5 lb-ft at 2,000 r.p.m. A compression ratio of 19 : 1 has been adopted.

Each of the three models of this vehicle has a gearbox with four forward speeds and one reverse. All four forward speed gears are equipped with synchronizers. The ratios are: top 1 : 1, third 1.717 : 1, second 3.01 : 1, first 5.56 : 1 and reverse 4.97 : 1. A final drive ratio of 5.428 : 1 has been adopted. Semi-elliptic springs are employed both for the front and the rear suspension, and they are fitted in conjunction with coil type assister springs with coaxial rubber bump stops. An anti-roll bar is installed at the front. Both the front and rear suspension systems are damped by telescopic, hydraulic shock absorbers. Disc type wheels,

Torsion bars are employed at the rear and a transverse semi-elliptic spring at the front of this D.K.W. chassis

with drop-base rims, 4.5E × 16, are employed; twin wheels are employed at each side at the rear.

So far as general layout is concerned, the cab-over-engine arrangement has been adopted to give the greatest possible platform area for the load. The vehicle structure is of semi-chassisless form. It has a frame comprising two box section longitudinal members with inverted top hat section cross members. The body, which helps to take the structural loads, is rubber-mounted on this frame. At the front, the assembly comprising the engine, steering and suspension, is carried on a sub-frame bolted beneath the main frame of the chassis.

In the bus body, the alternative seating arrangements illustrated are available, so that the vehicle can carry 10, 17 or 18 passengers in addition to the driver. The maximum load carried by the front axle is 2,640 lb, and on the rear axle it is 5,280 lb. A dry weight of 4,160 lb and a payload of 3,610 lb are quoted for the van. The ratio of dry weight to payload obtained with the pick-up is even better; the figures are 3,710 lb and 4,070 lb respectively.

The overall dimensions of the vehicles are as follows. All are 189¾in long except the pick-up, which is about 1in shorter, and all are about 81.9in wide. The loading platform of the pick-up is 118½in long × 74in wide, and that of the

DRY WEIGHTS OF VOLKSWAGEN COMMERCIAL VEHICLES

	Dry Weight, lb	Payload lb	Total weight, lb
Delivery van	2,025	1,827	4,070
Pick-up without tilt	2,090	1,760	4,070
Pick-up with tilt	2,090	1,682	4,070
Kombi	2,070	1,783	4,070
Micro Bus	2,395	1,628	4,070
Ambulance	2,605	1,410	4,070

In the Tempo Viking pick-up, the rear panel of the cab is of painted fibreboard

delivery van is 118.7in long × 74.4in wide. In the unladen condition, the height of the delivery van is 92.1in, and that of the pick-up is 88.2in. A wheelbase of 112.2in has been adopted, and the track is 63in at the front and 58.6in at the rear. The turning circle diameter is 37.6ft. In the bus, the following interior dimensions have been obtained; width at waist level 73¼in, and height above the floor 60.9in. In the laden condition, the floor is 24in above the ground.

All three versions might be described as of the semi-forward control type, since only part of the engine projects rearwards between the two front seats. The front end styling is arranged to accommodate the remainder of the engine in a forward position under a shelf that forms a continuation of the top of the facia. Also, the screen is set back a few inches from the profile of the front panel, below the waist. Access to the engine from the front, for normal service and maintenance, is obtained by removing the exterior panel; the engine cover between the front seats need be removed only for major work.

Goliath and D.K.W.

Because of the high cost of labour, small shops and other businesses are tending more and more to employ motor vehicles for delivery purposes instead of bicycles. This is because, despite the fairly high capital outlay, deliveries can be made at higher speeds, in larger quantities and more economically than is possible with a bicycle. For this reason, ultra-light commercial vehicles are popular on the Continent, and in some countries are used extensively. A range of such vehicles is offered on the Goliath three-wheeled chassis. This range includes both pick-ups and vans. The vans have

Above: these vehicles are two of a large range based on the D.K.W. chassis illustrated on the opposite page

Right: the double doors in the side of the Goliath commercial vehicle body are a good feature on both this passenger-carrying vehicle and the van version illustrated at the foot of this page

Above: the vans, buses and Kombi bodies on the Tempo chassis are basically similar

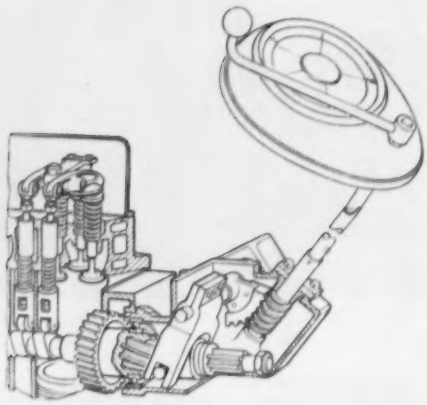
Below: the small bus among the range of vehicles built on this chassis by Ford of Cologne has a single door behind that for the driver

Above: the body panels of this Alfa Romeo van are common to those of a small bus body on the same type of chassis

Below: a low floor, as in this Goliath van, is essential for a body, the design of which is to be basically the same for a wide range of vehicles

The Tatra 111R chassis is of the backbone layout and all six wheels are driven

The Krupp compressor brake arrangement for their two-stroke engines



a door at the rear and they are also offered with a side door hinged at its forward edge. The engine of the latest model is an air-cooled, two-cylinder, two stroke unit with a bore and stroke of 67 mm and 70 mm respectively and a swept volume of 493.5 cm³. Its compression ratio is 6.5 : 1 and the power output is 17 b.h.p. at 4,250 r.p.m. The carburettor is a Solex 32 HR unit. An axial flow, ducted fan is employed to force the cooling air round the cylinders. A gearbox with four forward speeds and one reverse is provided. The ratios are: top 1 : 1, third 1.57 : 1, second 2.38 : 1, first 3.93 : 1 and reverse 5·09 : 1. Two axle ratios are offered, one is 8.6 : 1 and the other is 10.75 : 1.

The two side members of the frame are parallel between the semi-elliptic rear springs, which are carried by the ends of tubular cross members. Forward of the springs, the frame tapers to a point at the front end, where the engine is mounted. A quarter-elliptic spring carries the front wheel assembly. The mounting of this spring is unusual in that the spring is pivot-mounted immediately behind the attachment of the wheel unit; the suspension spring is attached at its thickest end to the wheel unit, and the other end trails and bears on the chassis frame. The front end of the body is supported on a cross member immediately above the pivot of the spring.

D.K.W. also offer a range of vehicles on a four-wheeled chassis. This range includes a delivery van, several types of pick-up, an ambulance, an 8-seater bus, and a Kombi, which is the equivalent of a shooting brake, but with a body basically of the commercial vehicle type of layout. This type of chassis is, of course, suitable as a basis for specialist coachbuilders' bodies and a number of coachbuilders offer variants of the standard versions. In the standard van, Kombi and bus, a single side door, hinged at its forward edge, is fitted in addition to a door at the rear. The Kombi and bus have three bench type seats, that at the front is for the driver and one passenger, while the other two are each for three people. The rear seat is mounted on top of the wheel arches so that there is a considerable amount of luggage space underneath it. Because this seat is higher than the rest, a footstool is fitted on the floor in front of it. The distance between the top of the squab and the waist rail at the rear is 15in. To give access to the rear seats, the portion of the centre seat squab nearest the door folds forwards.

Most of the body panels are common to the whole range of vehicles. In the bus, a sliding roof is fitted. The demand for these small buses is steadily increasing and most manufacturers offer models of this type. Probably the reason for their popularity is that they can be offered at a low price and are suitable for small parties, for example, for transport from hotels to the theatre and back, and also for collecting passengers and their luggage from railway stations.

The well known three-cylinder, two-stroke, water-cooled engine made by D.K.W. is used to power the vehicle. It has a bore of 71 mm and a stroke of 76 mm, giving a swept volume of 896 cm³. The engine has a compression ratio of 6.65 : 1 and develops 32 b.h.p. at 4,000 r.p.m. A four-speed gearbox is employed. The top speed ratio is 5.78 : 1, third 8.5 : 1, second 14.5 : 1, first 24.2 : 1 and reverse 29 : 1.

The frame comprises two longitudinal, box section side members, with one tubular cross member at the rear to carry the torsion bars for the single trailing link type suspension. Immediately forward of this cross member is an outrigger on each side to carry the body. Another cross member is fitted at an intermediate position to take the rear cab mountings and there is a third cross member at the extreme front end of the chassis. The front suspension comprises a transverse semi-elliptic spring, the ends of which form the upper links acting in conjunction with a wishbone type lower link on each side. Telescopic, hydraulic shock absorbers are

Left: a hydraulic jack is used to retract the trailing wheels of the Scania Vabis truck

Right: on the Volvo chassis, a chain and pulley on each side retracts the trailing wheels

employed on all four wheels. The front-wheel-drive arrangement is more or less conventional. A shaft from the clutch passes over the differential unit to the gearbox and the layshaft is below. The crown wheel pinion is on the forward end of the layshaft. A swinging half shaft on each side transmits the drive to the wheels.

Other manufacturers that make similar ranges of vehicles, including a bus and a Kombi, are Tempo, Ford of Cologne and Alfa Romeo. Some employ double doors at the side. This is a marked advantage in the vans because bulky objects can be loaded and unloaded easily. In the buses it obviates the necessity for employing pivoted seat squabs adjacent to the door to give access to the back. A wide variety of seating arrangements are adopted. Some manufacturers offer as many as four alternatives. A number of different vehicles of this type are shown in the accompanying illustrations, from which it can be seen that in every case, most of the body panels are common to the whole range. The success with which such a large number of types of body can be applied depends largely upon obtaining a low floor level.

Some interesting details of heavy commercial vehicles

The Tatra backbone type chassis, with all six wheels driven, was shown for the first time at Brussels although, of course, it is not new. The four rear wheels each have twin tyre equipment and single tyres are employed at the front. An air-cooled, V-12 engine is installed under the bonnet. This engine was first introduced over 20 years ago. It differs from the Magirus Deutz range in that it has two blowers instead of one for the air used to cool the cylinders. The cylinders have a bore and stroke of 110 mm and 130 mm respectively, giving a swept volume of 14.825 litres. They are set at an included angle of 75 deg. The unit develops 180 b.h.p. at 1,800 r.p.m.

A gearbox with four forward speeds and one reverse is employed in conjunction with a two-speed transfer box. The ratios are: top 1 : 1, third 1.62 : 1, second 2.78 : 1, first 5.29 : 1 and reverse 5.91 : 1, while the transfer box ratios are 1.82 : 1 for normal operation and 4.51 : 1 for emergency use. The gearbox and engine are mounted above the large diameter tube that forms the backbone and the two-speed transfer box forms part of the backbone component. The drive is transmitted both forwards and to the rear by propellor shafts inside the tube. Most of the components are common of all three axles. Each axle casing, of cylindrical form in line with the backbone tube, is flanged at its front and rear ends where it is bolted to the flanged tubular components of the frame. A transmission brake is fitted to the rear end of the back axle casing. Swinging half shafts drive the wheels. All four rear wheels are mounted on stub axle assemblies secured to the ends of semi-elliptic springs.

Tie rods are connected between the cross member, above the centres of the two semi-elliptic springs, and the stub axle assemblies to assist in locating them. There are two more cross members, one in front of, and the other behind, the twin axle assembly. Together with the central member, they carry the longitudinal side members of a frame on which the body is mounted. Another cross member immediately behind the front axle supports the forward end of this frame.

The front suspension is different, in that each side is supported by a quarter-elliptic spring. These springs are clamped to the central backbone, adjacent to the cross member that supports the front end of the body frame, and are inclined forwards and outwards so that they clear the swinging half shafts, which are in front of them. Tie rods are connected between the front end of the backbone and each stub axle assembly. Thus, as viewed in plan, the quarter-elliptic springs and two tie rods form a diamond shaped assembly, with the differential casing in the centre.

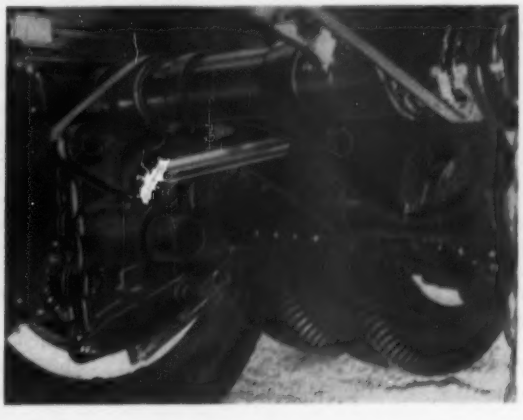
An unconventional steering gear arrangement has been adopted. The steering box is mounted on the cross member that supports the body frame. Its drop arm is connected by a link to a centrally pivoted lever that straddles the backbone tube. Each end of this lever is connected by a steering rod to the adjacent wheel assembly, which is well forward of it.

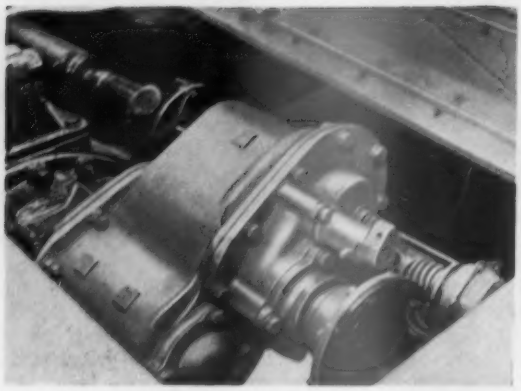
An interesting rear suspension system is employed on a Volvo three-axle chassis. Both the rear axles are driven. They are mounted on the ends of two centrally pivoted rocker arms, one on each side, under the frame side members. The pivot brackets are each beneath a platform, on which are two exceptionally large rubber blocks. Above the rubbers is an inverted platform bolted to the frame side member. There are also two locating links, one for each axle. These links are fitted between a cross member above the transverse bar on which the rockers pivot and a lug bolted to the top of each axle casing. With this arrangement, if one leading wheel rises, the trailing wheel tends to fall or alternatively the rocker pivot rises. However, the movement of the rocker pivot is no more than half that of the wheel, so that the deflection of the rubber only needs to be half as great as it would be if placed immediately over the axle of the rising wheel.

Other interesting features of this chassis include the method of transmitting the drive to the trailing axle, and the frame construction. The shaft from the gearbox is connected to a central spur gear of a set of three. One of the other two gears transmits the drive to the front axle and the other to

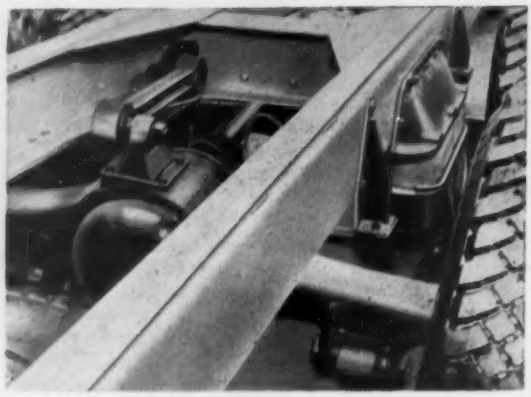
An unconventional suspension-spring mounting arrangement and pressed steel, body cross bearers are used on the M.A.N. 400 L1

A hydraulic jack actuates the chain pulley of the Volvo wheel retraction mechanism for the trailing wheels at the rear





The drive to the two rear axles on the Volvo chassis with rubber suspension



On each side of this Volvo chassis a rocker arm, with a rubber-mounted central pivot, carries the rear axles

the rear axle, as shown in the accompanying illustration. The frame is reinforced locally over the rubber suspension by a channel section welded in each side member. The flanges of this channel section are extended inwards to form gussets above and below the ends of the cross member between the two rubber units. Further reinforcement is provided by tack welding a strip of steel to the outer face of each flange of the side members. This is sound practice because practically all the bending loads, which impose the heaviest stresses, are taken in the flanges. The shear loading, which is taken in the vertical faces of the sections, is invariably relatively light.

Another exhibit on the Volvo stand was a Titan chassis with a retractable trailing axle. The object of retracting the trailing axle is to reduce tyre wear and increase efficiency when operating in the lightly laden or unladen conditions. It is also useful for eliminating the drag of the trailing axle and increasing the tractive effort obtainable from the driven axle for short periods when the vehicle is on slippery ground.

The trailing axle arrangement was described and illustrated in the February 1954 issue of *Automobile Engineer*. Briefly, its layout is as follows. There is a centrally pivoted rocker arm under each frame side member. The rear end of this arm carries the stub axle for the trailing wheel, and the front end carries the shackle at the rear end of the semi-elliptic spring of the front axle. In the Volvo truck, a chain is connected to the trailing end of the rocker and carried over a pulley to a bell crank lever on the end of a cross tube. This cross tube can be rotated by a hydraulic jack connected to a lever welded on mid-way between its ends. When the cross tube rotates, it pulls the chain over the pulley, lifting the trailing end and depressing the other end of the rocker, thus retracting the trailing wheels. Hydraulic power is obtained from a pump driven by an electric motor; the control is on the dash, so that the wheels can be retracted when the vehicle is in motion.

Scania Vabis exhibited a somewhat similar arrangement. The retraction mechanism on their vehicle is much simpler, but is actuated by a hand pump fitted, together with the hydraulic reservoir, on the rear end of the chassis. There are two hydraulic jacks, one on each side, mounted on the frame side members. When the jacks are extended, a forked fitting on the end of each arm engages over the forward end of the rocker arm that carries the spring shackle; it depresses this end of the arm and so lowers the spring shackle, while at the same time raising the wheel at the rear end. When the ram is retracted it is well clear of the suspension arm.

There were two interesting features on the M.A.N. 400 L1 chassis. One is the method of mounting the truck body and the other is the semi-elliptic spring arrangement of the front and rear suspension. The truck body is carried on pressed steel cross bearers, about $\frac{3}{16}$in thick. They are of channel section with lightening holes punched in them. Their flanged upper edges are straight, to carry the body, but their lower edges, which are also flanged, are arched between the frame side members and tapered, cantilever fashion, outboard of the frame side members. Above each frame side member a flanged channel section pressing is spot welded vertically on to the cross bearer to reinforce it locally where the heaviest compression loads are taken between the body and the side member. The main support for the body is afforded by two cross bearers, one immediately in front and the other immediately behind the rear wheels. These cross bearers have similar arched pressings bolted between them longitudinally over each side member. These four components form a platform, rectangular in shape as viewed from above, to support the body. There are three more transverse cross bearers, two in front of and one behind the rectangular platform over the rear axle.

The semi-elliptic spring attachment is unusual in that it has a slider pad arrangement at each end instead of the more conventional eye and shackle. Fore and aft location is effected by extending two of the lower leaves of the spring forwards and forming on them an eye which is pinned between lugs below each side of the front slider pad. This arrangement has the advantage that, because of the taper of the spring towards its ends, the two leaves that locate it are clear of the remainder over most of their length and therefore are subject to very little vertical loading. This means that the shear and bending stresses adjacent to the eye are exceptionally light and there is little danger of failure due to stress concentrations at that point.

Krupp exhibited two-stroke engines with their compressor brake incorporated. This is simply a device to alter the timing of the camshaft so that the overhead exhaust valves are closed every time the piston moves upwards. The half speed wheel has an extended hub in which are spiral splines. An internally and externally splined coupling is fitted on the end of the camshaft. Its external splines engage those in the half speed wheel and its internal ones, which are straight, engage splines on the camshaft. Therefore, axial movement of the coupling alters the angular relationship between the half speed wheel and the camshaft. The method of actuating this mechanism is shown in an accompanying illustration. It comprises a lever on the dash mounted on a spindle, at the lower end of which is a worm and segment gear actuating a rocker shaft arrangement that moves the sleeve. Progressive braking can be obtained as the lever is moved over its length of travel. The advantage of this system is that compression is effected in the cylinder instead of in the exhaust manifold.

GERMAN ALLOY STEELS

Some Notes on Present Practice to Conserve Scarce Materials

H. L. Waltl.

ALLOYED steels in common use on the Continent and especially in Germany are very different from those used in Great Britain. The German steels are laid down by the DIN-Norm, which is the equivalent to the British Standard Specification. The German standard analyses are given in Table I. On the first view it is amazing that only 3 out of 19 steels are nickel alloyed and none has a nickel content over 2·10 per cent. Even these three qualities are only used for special applications. For very heavy sections and for use in higher temperature ranges some chrome-nickel-molybdenum steels are used with max. 1·5 per cent Cr, 0·30—0·40 Mo and 1·8—2·0 per cent Ni, but supplies are scarce and they are difficult to obtain. Before and during the second world war the Continent had only very limited nickel resources and this alloying element had to be avoided. But even nowadays nickel is rather expensive.

Experience showed that the new leaner types of steel were very satisfactory. Fortunately from the psychological point of view, not one of these steels was really called 'ersatz' or 'substitute', which helped considerably for their common use. Certainly these lower alloyed steels required much closer control during their production and more specialized heat treatment than the more orthodox nickel steels. Therefore, the personnel for the heat treatment department had to be carefully trained. The importance of the proper heat treatment is also indicated by the great number of very good publications on this subject.

With regard to the different alloys, it is recognized that while the following alloying metals, manganese, chromium, molybdenum and nickel, all improve the toughness, nickel gives the best results. Thorough studies of the effect of individual alloys brought a steadily decreasing alloy content without lowering the behaviour of such steels; in fact, some have even superior fabricating properties. There are differences in the methods of choosing the right material for a specific part. In Germany there is a tendency to choose the steel with reference to all the necessary properties, such as wear, toughness, fatigue, etc., and to apply a heat treatment that will give optimum characteristics for the application. In the standards, tensile ranges in accordance with the mass effect are given but for use as a only guide.

Owing to the differences in analyses, a direct comparison between the German and the British steels is, not readily possible and only the ultimate tensile strengths, yield points, elongation, reduction of area and the impact test can be regarded as the basis for such a comparison. However, difficulties will be encountered in using the impact values and elongation for comparison purposes. The German standard for the gauge length of tensile test pieces is normally given as L = 5d against the British with L = 3·54d. This means that the elongation on the same steel would show in Great Britain a higher value than would be obtained with the German test specification.

The conversion of the impact values represents a still greater difficulty, since Germany uses a Charpy type test, whereas the Izod test is used in Great Britain. As the test is carried out in a completely different way, the relation between these values is difficult to establish, but as a rough, but still adequate guide, 1 ft-lb/in^2 can be estimated as equal to 0·5 kg/cm^2. Therefore, only the ultimate tensile strength and the yield point remain as figures useful for comparison. The reduction of area is not applicable since it is not stressed in the specifications of both countries. Owing to the difference in alloy content it is to be expected that the ratios between ultimate tensile strength and yield point will differ accordingly, and the calculation for a construction or machine cannot be based on the ultimate tensile strength without taking into account the yield point.

TABLE 1. STANDARD ANALYSES OF GERMAN ALLOY STEELS (1950)

Designation	Chemical Composition					
	Carbon	Manganese	Silicon	Nickel	Chromium	Molybdenum
Molybdenum-Free Carburizing Steels						
15 Cr 3	0·12—0·18	0·40—0·60	0·15—0·35	—	0·50—0·80	—
16 Mn Cr 5	0·14—0·19	1·00—1·30	0·15—0·35	—	0·80—1·10	—
20 Mn Cr 5	0·17—0·22	1·10—1·40	0·15—0·35	—	1·00—1·30	—
15 Cr Ni 6	0·12—0·17	0·40—0·60	0·15—0·35	1·40—1·70	1·40—1·70	—
18 Cr Ni 8	0·15—0·20	0·40—0·60	0·15—0·35	1·80—2·10	1·80—2·10	—
41 Cr 4	0·32—0·44	0·50—0·80	0·15—0·35	—	0·90—1·70	—
Low-Alloy Constructional Steels						
40 Mn 4	0·36—0·44	0·80—1·10	0·25—0·50	—	—	—
30 Mn 5	0·27—0·34	1·20—1·50	0·15—0·35	—	—	—
37 Mn Si 5	0·33—0·41	1·10—1·40	1·10—1·40	—	—	—
42 Mn V 7	0·38—0·45	1·60—1·90	0·15—0·35	—	—	—
34 Cr 4	0·30—0·37	0·50—0·80	0·15—0·35	—	0·90—1·20	—
41 Cr 4	0·38—0·44	0·50—0·80	0·15—0·35	—	0·90—1·20	—
25 Cr Mo 4	0·22—0·29	0·50—0·80	0·15—0·35	—	0·90—1·20	0·15—0·25
34 Cr Mo 4	0·30—0·37	0·50—0·80	0·15—0·35	—	0·90—1·20	0·15—0·25
42 Cr Mo 4	0·38—0·45	0·50—0·80	0·15—0·35	—	0·90—1·20	0·15—0·25
50 Cr Mo 4	0·46—0·54	0·50—0·80	0·15—0·35	—	0·90—1·20	0·15—0·25
30 Cr Mo V 9	0·26—0·34	0·40—0·70	0·15—0·35	—	2·30—2·70	0·15—0·25
36 CrNiMo 4	0·32—0·40	0·50—0·80	0·15—0·35	0·90—1·20	0·90—1·20	0·15—0·25
34 CrNiMo 6	0·30—0·38	0·40—0·70	0·15—0·35	1·40—1·70	1·40—1·70	0·15—0·25
30 CrNiMo 8	0·26—0·34	0·30—0·60	0·15—0·35	1·80—2·10	1·80—2·10	0·25—0·35

TABLE II. HEAT TREATMENT STEELS

British Specification	Size up to inches	U.T.S. tons in²	German Specification
E N 8	2	40	C 60, CK 60, St 60.11
	½	45	C 45, CK 45, St 60.11
E N 9	1½	50	C 60, CK 60, St 60.11
	1½	55	40 Mn 4, 30 Mn 4, 25 Cr Mo 4
E N 11	2½	55	42 MV 7, 50 CrV 4, 42 CrMo 4, 36 CrNiMo 4
	2½	65	
E N 12	6	40	37 MnSi 5, 34 Cr 4, 41 Cr 4, 36 Cr 4, 34 CrMo 4
E N 13	6	40	37 MnSi 5, 34 Cr 4, 41 Cr 4, 36 Cr 4, 34 CrMo 4
E N 14, A, B	4	40	C 60, CK 60
	2½	45	
E N 15, A,	½	50	40 Mn 4, 30 Mn 5, 25 CrMo 4
	2½	45	
	4	40	CK 60, C 60
E N 15, B	½	55	CK 60, C 60
	½	50	
	2½	45	37 MnSi 5, 34 Cr 4, 41 Cr 4, 34 CrMo 4, 36 Cr 6
	4	40	CK 60, C 60
E N 16	½	65	42 MV 7, 42 CrMo4, 36 CrNiMo 4, 48 CRV 6
	6	45	
E N 17	1½	65	42 MV 7, 42 CrMo 4, 36 CrNiMo 4, 42 CrV 6
	2½	60	
	4	55	
	6	50	
E N 18	1½	55	37 MnSi 5, 34 Cr 4, 41 Cr 4, 34 CrMo 4, 36 Cr 6
	2½	50	
	4	45	
E N 19	½	65	42 MV 7, 42 CrMo 4, 36 CrNiMo 4, 42 CrV 6
	6	45	
E N 20	1½	65	42 MV 7, 42 CrMo 4, 36 CrNiMo 4, 42 CrV 6
	2½	55	
E N 21	2½	50	42 MV 7, 42 CrMo 4, 36 CrNiMo 4, 42 CrV 6
	4	45	37 MnSi 5, 34 Cr 4, 41 Cr 4, 34 CrMo 4, 36 Cr 6
E N 22	2½	55	42 MV 7, 42 Mo 4, 36 CrNiMo 4, 42 CrV 6
	4	50	
E N 23	2½	65	50 CrMo 4, 34 CrNiMo 6, 50 CrV 4
	6	60	30 CrMoV 9, 30 CrNiMo 8
	6	55	
	6	50	50 CrMo 4, 34 CrNiMo 6, 50 CrV 4

British Specification	Size up to inches	U.T.S. tons in²	German Specification
E N 24	1½	100	30 CrNiMo 8, 30 CrMoV 9
	1½	80	
	1½	75	
	1¾	70	50 CrMo 4, 50 CrV 4, 34 CrNiMo 6
	2½	65	
	4	60	
	6	55	30 CrMoV 9, 30 CrNiMo 8
	6	50	50 CrMo 4, 40 CrV 4, 34 CrNiMo 6
E N 25	2½	100	30 CrMoV 9, 30 CrNiMo 8
	6	65	
E N 26	4	100	special propriator steels
	6	65	
	6	60	30 CrMoV 9, 30 CrNiMo 8
E N 27	4	70	30 CrMoV 9, CrNiMo 8
	6	65	
E N 28	2½	80	30 CrMoV 9, CrNiMo 8
	6	65	
E N 29	2½	100	30 CrMoV9, CrNiMo 8
	4	70	
	4	65	50 CrMo 4, 34 CrNiMo 6, 50 CrV 4
	6	60	30 CrMoV 9, CrNiMo 8
	6	50	50 CrMo 4, 34 CrNiMo 6, 50 CrV 4
	6	45	42 MV 7, 42 CrV 6, 42 CrMo 4, 36 CrNiMo 4
E N 30			Special propriator steel
E N 31			steel for ball bearings
E N 100	1½	65	42 MV 7, 42 CrV 6, 42 CrMo 4, 36 CrNiMo
	6	45	
E N 110	1½	70	50 CrMo 4, 34 CrNiMo 6, 50 CrV 4
	1½	65	42 MV 7, 42 CrMo 4, 36 CrNiMo 4, 42 CrV 6
	6	45	
	6	55	50 CrMo 4, 34 CrNiMo 6, 50 CrV 4
E N 111	1½	60	42 MV 7, 42 CrMo 4, 36 CrNiMo 4, 42 CrV 6
	6	45	
E N 160	1½	60	42 MV 7, 42 CrMo 4, 36 CrNiMo 4, 42 CrV 6
	6	45	

British steels tend to have a much higher ratio than the German steels. On smaller diameters where, after hardening, a higher percentage on martensite can be reached this ratio can amount to approximately between 90 and 95 per cent. In the German steels the ratio is only about 80—85 per cent. In both cases the ratio decreases with increasing mass effect. It is not so essential to take this ratio into account with British steels of the higher alloyed qualities as it is with German steels. In this respect the heat treatment can be of importance. Comparing the different steel qualities from this point of view, it will be found that for similar applications a higher ultimate tensile strength will be asked for in Germany than in Great Britain.

In Table II the main British standard steels are compared with those of the DIN-Norm.

Case hardening steels

There are but few German steels of case hardening quality, in which nickel is an alloying element. In this connection, it is interesting that frequent references are made in German technical publications to the better machinability of chromium-molybdenum steels whereby a longer tool life may be obtained or higher cutting speeds may be employed. However, for these steels the hardening temperature is slightly higher which leads to a slight increase of distortion on more intricate shapes. The hardness of the case is slightly higher than those of nickel-steels and they have the advantage of being particularly free of retained austenite which easily remains in hardened Ni-Cr steels, particularly above 3 per cent nickel. The Cr-Mn steels for case hardening also have good machinability. They call for the same treatment and will give the same results as the Cr-Mo steels, but they have the advantage that no molybdenum—an element which is scarce on the Continent—is used.

In the few Cr Ni steels for case hardening, the nickel and chrome are balanced so that they equal each other. This gives the optimum combination of toughness, and strength. Such steels are used only for very heavily loaded truck parts or for similar really severe services. It may be of interest that martempering is used in connection with case hardening in order to avoid distortion. Close control of the carburizing cycle is essential and quick-acting compounds have to be avoided, because Cr-Mo and Cr-Mn steels readily form cementite. Carburizing is mostly done in saltbaths or for smaller parts by the homocarb (drip-feed) process.

Heat treatment steels

The same trend to avoid all expensive and scarce alloying elements prevails in the case of steels for heat treatment. Where Ni-Cr steels are specified, they are balanced in the same way as the case hardening steels, Ni being equal to Cr. These Ni-Cr steels are for special purposes only.

It is interesting that the various lean-alloyed DIN steel qualities are widely used for gears. Use is made of the various types of surface hardening. For pinions with small teeth, the steel quality 58 CrV 4, with about 58 per cent C, 1 per cent Mn, 1·1 per cent Cr and 0·15 per cent V is used, and the teeth only are through-hardened by the rotary hardening process. On wheels with bigger sized teeth the teeth are surface-hardened individually. In this way, a high core hardness can easily be obtained, alloying elements saved and the weight of moving parts decreased. Obviously great care has to be taken on some of the German steels to avoid brittleness and temper-brittleness, but publications on brittle fractures show that it can be done with most careful heat treatment.

For gears on cars, etc., both case hardening steels and steels for heat treatment with about 0·30—0·45 C are used. These heat treatment steels will be slightly carbonitrided to about 0·010 in and afterwards heat treated to a surface hardness of about 58 Rockwell C. The corresponding core hardness will be about 95—105 ton/in^2. Such gears have less distortion, and the distortion is more regular and therefore easier to keep under control, than gears made of case hardening steels. If salt baths are used, it is not necessary to grind the gears after heat treatment. Such gears made from 42 MnV 7, 37 Mn-Si 5, Ck 35, are considered equal to those of case hardening steels 18 Cr-Ni 8, 15 Cr-Ni6, 20 Mn-Cr 5, 16 Mn-Cr 5, in their performance as far as the endurance limit is concerned. In Austria a steel with 0·40—0·60 Si, 0·45—0·60 Mn is successfully used for car and tractor gears. Jominy test data for a few of the more important steels are given Table III.

In one research publications it is stated that of the steel qualities Ck 45, Ck 60, 30 Mn 5, 37 Mn-Si 5, 50 Cr-V 4, 42 MV 7, 34 Cr 4, and 41 Cr 4, the alloyed steels are superior to the manganese or unalloyed steels, as regards ultimate tensile strength at the same tempering temperature. There is, however, no definite superiority regarding elongation. Of these steels the 2·5 Cr and 0·3 V steels have the best impact resistance. Generally, the tendency in Germany is to obtain the necessary mechanical properties, at least in part, by using higher carbon contents. During and immediately after the second world war the steels were so lean alloyed that the specified values left little safety margin for heat treatment. Since 1950, alloy contents have been increased but are still considerably less those which are considered normal in the British car and gear industry.

TABLE III. JOMINY TEST DATA

Steel Specification	Hardening Temp. deg C	50 per cent Martensit mm	Ideal critical dia mm	Critical Dia. water mm	Critical Dia. oil mm
Ck 35	850	5	36	27	10
Ck 45	830	6	43	32	15
Ck 60	810	7	50	37	18
40 Mn 4	830	8	55	45	23
30 Mn 5	840	12	72	63	35
VM 175	820	15	84	72	44
37 MnSi 5	850	13,5	78	68	40
42 MnV 7	850	17	89	78	49
34 CrAl 6	900	13	77	66	38
34 Cr 4	830	17	89	78	49
50 CV 4	830	18	94	82	52
34 CrMo 4	850	20	100	88	57
30 CrMoV 9	850	65	181	170	135

A few nitriding steels are also in use. One of the main representatives is mentioned in Table II, the others are more or less of similar chemical composition. On the Continent, nitriding is generally done in salt baths and only for very small and intricate shapes is gas nitriding considered better. By using not more than 560 degC in the salt bath, brittle nitride layers can be avoided, as also can spalling.

Spring Steels

For spring steels there is a tendency to use cheap alloying elements in fairly low percentages. Among the main spring steels are those of the manganese type, which were originally used in the south of Germany and Austria because the ores used contain sufficient manganese to avoid the necessity of adding alloying elements. These steels are mostly of the oil hardening type, with about 0·65 per cent carbon, since manganese steels of lower carbon content tend to develop hardening cracks. To improve these steels the sulphur

TABLE IV. CHEMICAL COMPOSITION OF SPRING STEEL

Specification	C	Si	Mn	Cr	V	indicated use
50 M 7	0·45—0·55	max. 0·4	1·5—2·0	—	—	for cars
48 S 7	0·40—0·55	1·5—1·8	0·5—0·75	—	—	for railways
55 S 7	0·50—0·60	1·4—1·9	0·5—0·9	—	—	for tramcars, and lorries
65 S 7	0·60—0·70	1·4—1·9	0·5—0·9	—	—	
50 CV 4	0·45—0·55	max. 0·4	0·6—0·9	0·9—1·2	0·1	for cars

content has purposely been kept fairly high to get a great number of sulphur manganese inclusions, which after rolling produce a desirable structure. Superior to this steel and therefore now commonly used are the silicon steel swith about 1·4—2·0 per cent silicon and 0·5—1·0 per cent manganese. They are not as difficult to heat treat as the manganese steels, which have only a very small temperature hardening range, and in addition they are not expensive with regard to alloying elements.

Silicon steels with about 3 per cent Si have also been used, but they have the drawback that the high Si content causes an increase of decarburization when heat treated. Some of the melts may easily give black heart fracture (graphite precipitation). For shock-loaded springs Cr-Si steels are used. These steels are not as susceptible to overheating and decarburization. Furthermore, they can be used up to 300 degC, and are therefore suitable for valve springs and similar applications.

The best steel is a chrome-vanadium type with about 0·5 C, 0·8 Mn, 1·0 per cent Cr and 0·10 per cent V, for sizes up to about 1½ in diameter. For bigger dimensions the carbon content is increased to about 0·58 per cent, with 1·0 per cent Mn, 1·10 per cent Cr, and 0·10 per cent V are used. These steels are not susceptible to overheating, have a good through-hardening effect and a good resistance against decarburization. Furthermore, their ratio of yield stress to ultimate tensile strength is very favourable and even at 105 ton/in² the impact value is adequate.

Normally, oil hardened steels are used for torsion bar springs to eliminate hardening cracks as far as possible. There has been also quite an amount of investigation to increase the fatigue resistance by shot blasting, and also by burnishing and peening, two processes which have been used with success for torsion bar springs and valve springs. Attention has also been paid to a decrease in the fatigue effect of corrosion by using plating with cadmium, chromium and zinc, or by other means such as varnishing.

Normally, for car valves, the 0·65 C, 0·20 Si and 0·50 per cent Mn steels are used. They are given special cold drawing and hardening. For very highly stressed springs the wire is very finely ground and polished. Steels for use at temperatures above 300 degC are given in Table IV. As can be seen steel qualities for springs are not so very different from British spring steel types. From all these points it is obvious that there is still a tendency to use as little as possible of alloying elements stressed and research and investigation into the possibilities of further reductions are still going on.

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INSTITUTION OF MECHANICAL ENGINEERS

February Meetings of the Automobile Division

London

Tuesday, 14th February, 5.30 p.m., at 1 Birdcage Walk, Westminster, S.W.1. Paper: "The M.I.R.A. Proving Ground," by Dr. A. Fogg (Member).

Birmingham

Tuesday, 28th February, 6.30 p.m. in the James Watt Memorial Institute, Great Charles Street. Address by the Chairman of the Automobile Division, Dr. C. G. Williams, (Member) entitled "Some Experiences of Automobile Research".

Derby

Monday, 20th February, 7.15 p.m. in the Midland Hotel, Derby. Paper: "Fabrication Methods in Light Engineering", by N. D. G. Mountford.

Luton

Monday, 13th February, 7.30 p.m., in the Assembly Hall, Luton Town Hall. Paper: "The Application of Plastics to the Manufacture of Automobile Bodies and Components," by D. S. Mahon.

North-Eastern

Wednesday, 15th February, 7.30 p.m. in the Chemistry Lecture Theatre, The University, Leeds. Paper: "The Application of Plastics to the Manufacture of Automobile Bodies and Components", by D. S. Mahon.

North-Western

Thursday, 23rd February, 7.15 p.m. in the Engineers' Club, Manchester. Paper: "Ball and Roller Bearing Development", by M. J. Knaggs, (Member).

Scottish

Monday, 20th February, 7.30 p.m. in the Institution of Engineers and Shipbuilders, 39 Elmbank Crescent, Glasgow. Paper: "Sales and Service in the Transport Industry" by J. M. Forbes, (Member).

Western

Thursday, February 23rd, 6.45 p.m. in the Royal Hotel, Bristol. Address by the Chairman of the Centre, Mr. R. C. Cross, (Member) "A Precision Wire Forming Development".

This view of the main assembly shop before reorganization indicates the congestion prevailing when the increased rate of production began to exceed the capacity of the then-existing assembly system

Vacuum Braking Equipment Manufacture

Methods Introduced at the Clayton Dewandre Works to Cope with Rapidly Expanding Output. PART I.

In recent years the rising output of motor vehicles, in conjunction with the wider application of power-assisted braking systems, has resulted in heavy demands being made on the productive capacity of the Clayton Dewandre Co. Ltd. of Lincoln, manufacturers of both vacuum and pressure braking equipment. In the three years to 1953-4 output was doubled. By that time capacity was taxed to the utmost, considerable overtime was being worked, shops were crowded and benches were congested with part-finished units and work in hand.

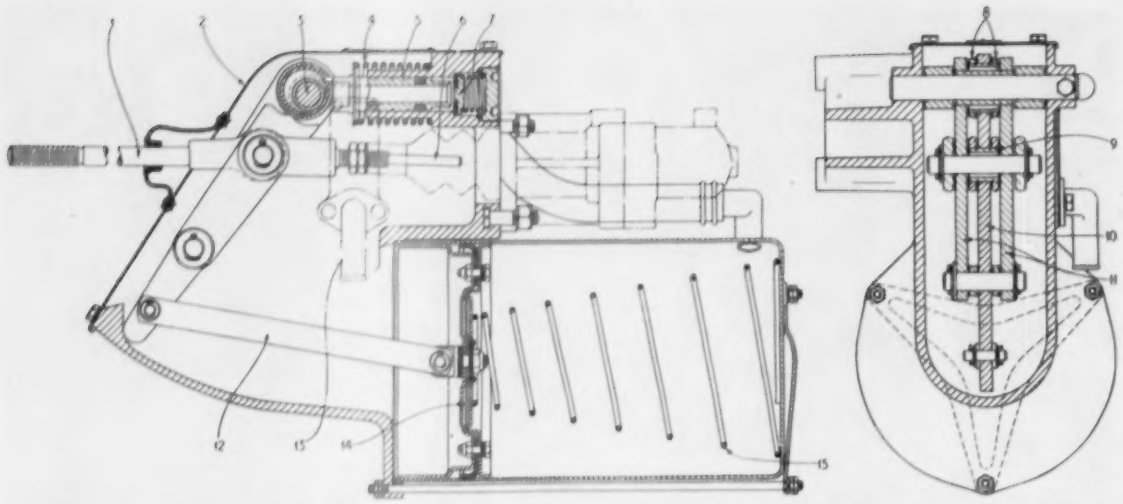
Site considerations were inflexible and exercised a dominating influence. The existing plant, in the main, was comprised of a single building, nearly 1,000 ft. long, in which the ground floor was occupied by machine tools and the floor above was used for assembly, stores and certain light operations. Assembly was arranged on benches running across the shop. Sets of matched parts were stacked at one end of the bench and the work was progressed along the bench manually to the final assembly and returned to the test station at the same end.

Work was "jobbed" to individuals and to small gangs and, as output was increased, delays were experienced owing to imperfect co-ordination of gang output and to time lost in waiting for parts behind schedule. At all times a large quantity of material, most of it partly processed, was static on the benches. Some idea of the amount of material standing in the shop, and the consequent congestion, can be gathered from the general view of the assembly shop at that period.

A decision was taken to re-organize, and assembly, which was in most urgent need of attention, was tackled first. A careful study was made of materials handling; transfer; operation timing, sequence and grouping; and an investigation made of longer lines arranged longitudinally. To ensure the flexibility necessary to handle a fairly wide range of products it was decided, however, to retain relatively short transverse lines, each comprising a power-driven, continuously running belt transfer track with work stations arranged on both sides. These lines run in the same direction as the route followed on the earlier bench method. Sets of parts and materials are collected in the stores and are fed directly to the start of the lines as required. At the end of the lines, finished and tested components are stacked into stillages which are transferred by Lansing-Bagnall pallet trucks and then lowered on a hoist to the dispatch department on the ground floor.

Certain lines are occupied on sub-assemblies or detail assemblies–distributor valves are an example–and these items are tested at the ends of the lines and then transferred to store for subsequent issue to the main assembly lines. Most lines are continuously engaged on a single type of component but one line is equipped to assemble smaller batches of a variety of components for which there is relatively less demand. The foregoing remarks refer specifically to the assembly of vacuum servo equipment but are characteristic and, in general, are applicable to the pressure braking equipment and vehicle heater sections also.

On the introduction of the new methods, improvement was soon apparent in the smoother flow of work through the shop, the absence of congestion, and improved working conditions. All the advantages could not, of course, be fully realized immediately. In the first year, however, despite the attendant difficulties of a new layout, new routing of materials, new shop equipment and the necessary adjustments of operating routine and habits, an increase in output of 25 per cent was achieved with the same number of operatives. Moreover, the working of overtime was progressively reduced and eventually, in all but exceptional circumstances, was eliminated. Now the system has "shaken down" results are more impressive. To quote an instance, the gang



Arrangement of VH2/687 vacuum hydraulic master servo: **1.** *Input rod* **2.** *Cover* **3.** *Lever shaft* **4.** *Valve plunger spring* **5.** *Distributor valve plunger* **6.** *Push rod* **7.** *Disc valve* **8.** *Rollers* **9.** *Distance bush* **10.** *Reaction lever* **11.** *Brake levers* **12.** *Piston links.* **13.** *Breather elbow* **14.** *Piston* **15.** *Piston return spring*

assembling the 110 mm vacuum hydraulic servo in the past produced 700 units in a week of 66 hours. The same gang, working as a single team on a flow line, currently build 1,300 units in a 44-hour week. Its record output was 1,400 units in a standard week. The component in question is the VH1/433 type vacuum hydraulic master servo with a pressed light alloy detachable cylinder. Variants are fitted with either a Lockheed or a Girling master cylinder.

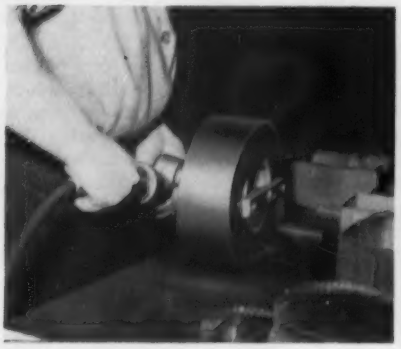
On the line for the VH2/687 unit—a larger version of the VH1/433—there are eight stations and the sequence of grouped operations is as follows :

1. Fit vacuum connections and hose to lever housing ; fit distributor valve and plug. Place housing on flow line.
2. Wire ferrule into input rod gaiter ; rivet gaiter to top cover ; make up cylinder tie rods and yoke. Place top cover and yoke on flow line.
3. Assemble vacuum piston in ring fixture ; attach links. Place on flow line.
4. Make up operating lever assembly complete, including pressing in bushes. Place on flow line.
5. Take piston and links from flow line ; grease piston leather ; attach return spring ; insert piston into pressed cylinder and operate to check freedom of movement. Take lever housing and yoke from flow line. Attach cylinder and piston assembly to lever housing with yoke and return to flow line.
6. Take servo assembly, as from station 5, and also operating lever assembly from flow line. Insert levers into lever housing and attach to piston links. Return assembly to flow line.
7. Take assembly from flow line and test ; loose fit hydraulic master cylinder and return to flow line.

View of two lines for the assembly of vacuum hydraulic master servo units. An adjustable light is provided at each work station

Riveting input rod gaiter to servo top cover; a sub-assembly operation off the line

Air-operated ejection of servo piston from assembly jig



For pistons having a single central clamping member a horizontal jig is used and no extractor mechanism is necessary.

Utilization of vehicle pressure brake unit and hand control on piston assembly bench

8. Take assembly and top cover from flow line. Lubricate levers; tighten down master cylinder and set plunger clearance; check for correct assembly; attach top cover. Place in stillage.

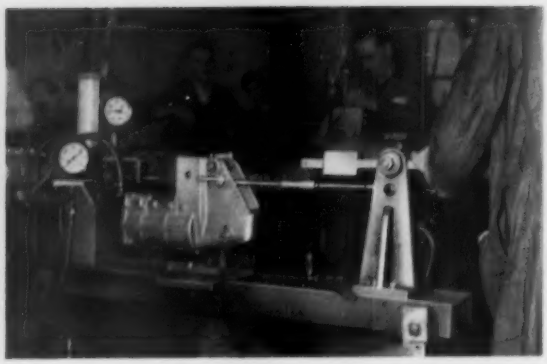
Throughout the line the maximum use is made of air-operated hand drills and nut runners of Desoutter manufacture, but for certain screws or nuts in confined locations special cranked spanners are provided. At station 2 a loose metal flange is fitted over the gaiter and secured by hand-clinched bifurcated copper rivets to the top cover. For some of the lines handling basically similar components, these parts are issued complete as a sub-assembly. The operation is then performed at a riveting station off the line on one of a pair of air-operated, pedal-controlled presses built by the Bifurcated and Tubular Rivet Co. Ltd. At each of its four holes, the cover is located on the clinching anvil; the rivet, of steel in this instance, is fed down a slide and entered into a hole in the metal flange; and is then punched through the flange of the rubber gaiter and clinched. This work is batched and returned to store.

The operating lever linkage is built-up to form a sub-assembly

Importance is attached to this operation and a sound water-proof joint is required. This is regarded as an essential owing to the relatively exposed position of the servo unit on the vehicle chassis, in many instances. Should water be permitted to enter, the danger might arise of the operating lever system becoming frozen-up in cold weather, with consequent loss of braking capacity.

The piston comprises two steel pressings that clamp a cup leather backed by a brass disc which has a serrated flange to support the lip of the leather. These parts are assembled in a recessed circular jig rigidly mounted at station 3, the main items being located from their peripheries. First, the base of the jig is loaded with six clamping bolts and a nut for the central eye bolt, each being seated in a hexagonal recess to prevent rotation. Above the central nut is located the clip washer for the attachment of the piston return spring. Over these bolts the crown pressing, cup leather, brass expander, and skirt pressing are successively inserted in the jig, and the eye bolt is entered in its

Wooden cradles are used to support components in the later stages of assembly



Servo units are tested at a station on the assembly line

nut and screwed home. Nuts are fitted to the clamping bolts and are screwed up by a nut runner. To complete the operation the two piston links are secured to the eye bolt by means of a pin retained by washers and split pins.

Since the assembly has to be withdrawn from the jig against the action of the cup leather, a mechanical ejector mechanism is provided. This is a typical example of the manner in which component units of the Company's own vehicle equipment have been adapted for use in production or assembly at various points in the plant. As shown in the low-level view of this station, a standard diaphragm type pressure braking unit is mounted immediately below the assembly jig to actuate an ejector plunger which abuts the end of the piston eye bolt. Pressure air is taken from the shop line and control is by a standard hand control valve mounted conveniently at bench level.

On certain other servo units the piston parts, of similar design, are clamped together solely by a central eye bolt. These are assembled in a horizontal ring jig having a parallel through bore. The eye bolt nut is held against rotation by means of a detachable latch bar and when this is removed the assembled piston can be pushed easily through the jig and withdrawn.

For the operating lever assembly at station 4 a simple location jig, raised to convenient working height above the bench on a bridge fixture, is used to position the links and rods and align all pivot holes. Bushes are inserted in the links on an arbor press mounted immediately to the left of the jig. The links are built up on the jig, with spacers, rollers, and the fork ends of the input and operating rods, pins are inserted and secured with washers and split pins.

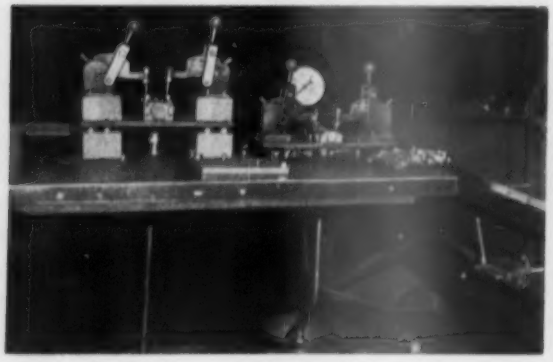
At the next station the assembly takes shape, the piston and its return spring being fitted in the deep-drawn light alloy cylinder, which is then attached to the cast light alloy lever housing by means of the tie rods and yoke. Thereafter it is handled at each station in a wooden cradle. These are of the simplest construction and are designed to support it loosely whilst permitting the operator to tilt it for convenience in working. A metal stem attached to the base of the cradle is passed through an axial hole in a circular metal plate mounted on the bench, and on this the cradle can be swung through 360 deg. It is not secured in any way and when a different component is to be assembled on the line the cradles are merely lifted out of their mountings and replaced by others of suitable pattern.

After the operating lever assembly has been fitted at station 6 the component is set up on a test stand alongside the line. Here a check is made that the unit holds vacuum satisfactorily, the tester imposes a load on the input rod and observes the thrust of the operating rod to check that the appropriate multiplication of effort is secured. On completion of the tests the hydraulic master cylinder is fitted loosely in position and the unit returned to the line.

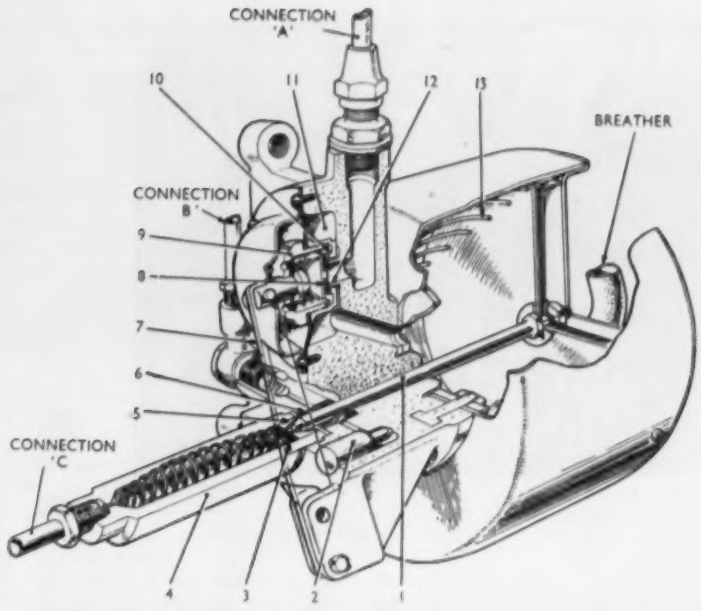
At the last station the hydraulic cylinder is secured, clearances set, the general assembly is checked, operating levers are lubricated and the top cover enclosing the operating levers is fitted. On leaving the line the component is placed in a stillage for transport to the dispatch department.

One line is arranged for the assembly of distribution valves of various patterns to suit different types of servo unit. Since most of the work is hand fitting or assembly of small parts, and the maximum flexibility to handle different

Test rigs at the end of the distributor valve line are duplicated to handle units of different sizes



Fitting the piston and the end cover on a V.O.M. servo unit supported on a tilting fixture



Arrangement of V.O.M. type vacuum hydraulic servo: **1.** *Piston rod* **2.** *Hydraulic input plunger* **3.** *Output plunger seal* **4.** *Hydraulic output cylinder* **5.** *Output plunger* **6.** *Input chamber* **7.** *Valve lever* **8.** *Valve disc* **9.** *Valve cage* **10.** *Atmosphere valve* **11.** *Diaphragm vacuum chamber* **12.** *Vacuum inlet port* **13.** *Piston return spring* A *Vacuum inlet* B *Input from master cylinder* C *To wheel cylinders*

The test rig for the V.O.M. servo unit incorporates arrangements for bleeding the hydraulic circuit

Air-operated press for marking identification plates

components must be maintained, the benches have but few fixtures or mounted tools. Where fixtures can be usefully employed they are usually of a multiple type to accommodate two or three items of similar pattern but of different sizes. Compressed air hand tools are used for driving screws and running nuts. At the end of the line is a test station and on this also the fixtures are duplicated to enable a range of different-sized units to be tested. With vacuum valves there is no need to make screwed connections, and the unit is merely held up to the vacuum line orifice and then secured in position by a pair of toggle clamps. Both fixtures are fed by a common vacuum line controlled by a single hand valve. While one fixture is being used the other is blanked off with a dummy component.

V.O.M. type vacuum hydraulic car servo units are assembled on further transverse flow lines. As these components are of basically different design, the assembly fixtures are necessarily also of different type and some assembly procedures are modified. The valve casing is bolted directly to the closed, vacuum end of the cylinder and the piston rod passes through a seal in the casing to operate an axially aligned hydraulic output cylinder. The piston assembly is jigged to ensure concentricity.

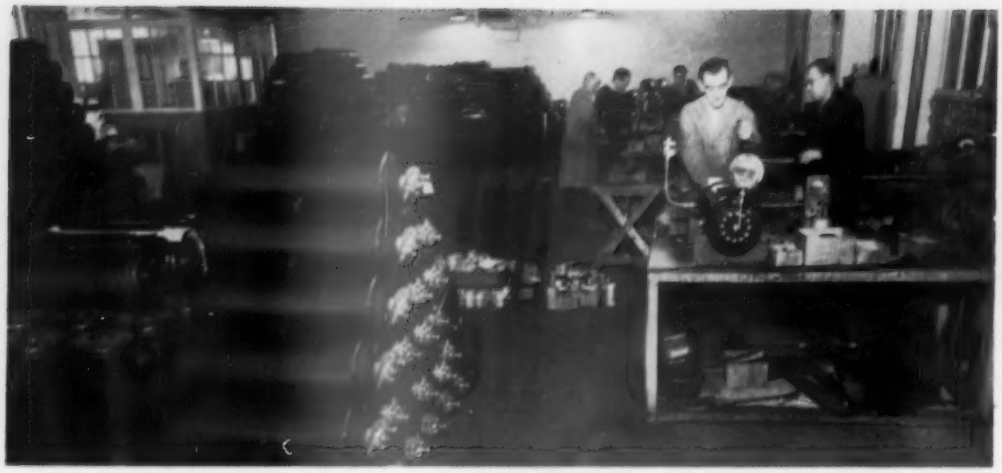
Input is not applied mechanically, as in the VH type servos, but hydraulically, being supplied by a master cylinder operated by the vehicle brake pedal. To obviate the possibility of damage to the rubber sealing members, no mineral oil is used. Lubrication is effected by Girling Crimson brake fluid and a special silicone grease is used for the piston cup leather. Output of this model has been raised by 75 per cent since reorganization.

A horizontally pivoted fixture is used to support the cylinder and valve casing during fitting of the piston and the cylinder end cover. The work is merely pushed on to the pivoted member, mounting holes in the casing bracket being engaged on pins for positive location, and can then be tilted backward or forward through limited angles for convenience in working.

As a consequence of the hydraulic input to operate this servo, it follows that the hydraulic system must be charged before it can be tested. This necessitates a different type of test stand on which hydraulic fluid can be circulated from a tank and through the servo until all air is expelled. The circuit includes sight glasses mounted alongside the gauge board for convenient observation and when all evidence of air in the flow has ceased, the system is closed. Thereafter the test routine is started, the input being provided by a master valve which is foot-operated by a lever fitted with a stirrup.

The Bendix Hydrovac unit, manufactured under licence, is produced on a similar line. An interesting feature is the riveting up of the diaphragm valve assembly of this servo for which a special compressed air press is provided. The ram slides in a substantial yoke member that is adjustably clamped on a solid vertical column. Operation is by means of a vehicle pressure braking cylinder mounted on top of the yoke and a sensitive control can be exercised by a standard pedal valve. An illustration of this press appears on the Contents page.

All components carry an identification plate and the marking of these, in view of the quantities involved, has necessarily been mechanised. An operator is continuously engaged on this work on an air-operated marking press by the Mead Specialities Co. of Chicago. A range of standard dies for the various components is maintained and the work



View of vacuum reservoir assembly shop

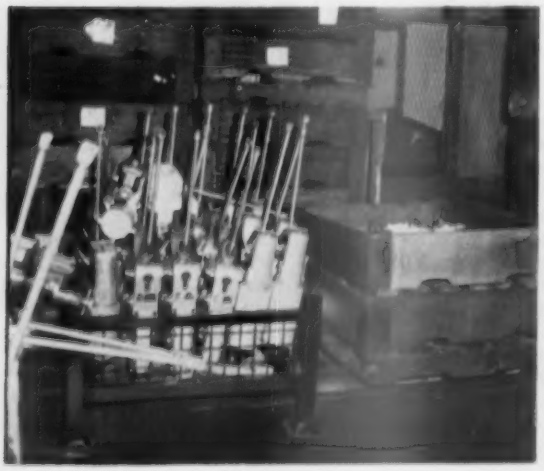
is batched to suit the flow of production. A plate is located face downwards on the die mounted on the press table and the ram imposes a predetermined load to produce neatly incised characters and numerals. Control of the press is by the simultaneous operation of two widely spaced valves mounted on the front of the table to ensure that the operator has both hands out of the path of the ram.

Usually a vacuum reservoir is incorporated in the braking system. This is fitted in the vacuum pipe between the engine induction manifold and the servo unit to maintain a constant working vacuum. Moreover, it provides a reserve adequate for several brake applications and thus ensures that the brakes remain fully operative should the engine be suddenly stalled. The vacuum is maintained in the reservoir by means of a non-return valve at the connection from the engine manifold.

These relatively bulky components are bought in and are coated, assembled and tested in a special ground-floor department. The reservoirs are blown out internally and wire-brushed externally and then washed in white spirit. In a fully-hooded booth, from which fumes are continuously extracted, they are spray enamelled inside and out while supported horizontally. The interior is completely coated by inserting the nozzle of the spray gun through two orifices. They are then placed vertically on special multiple fixtures in an oven for stoving. In the assembly shop the non-return valve, the connections and fittings are built up as units and are then fitted to the reservoir. After testing for soundness and final inspection they are stacked ready for dispatch.

Links, levers, bushes, pins, screws, bolts, washers, covers and various other parts of the servo units are bright zinc plated by the "Canning" process. This is the standard plating treatment used for these and for many parts from other products manufactured by the firm. The plating department, at ground level, is completely mechanized and, judged in relation to its work output, is remarkably compact. The weekly through-put ranges from 15 to 17

In the dispatch department components are transferred from a shop stillage to a transport pallet



Barrel plating small parts. Work being transferred from a metal to an ebonite barrel after cleaning

tons of work, practically all of which consists of small items. All equipment is of Efco-Udylite manufacture and comprises a fully automatic plant with two continuously operating looped tracks and a barrel-plating plant consisting of parallel cleaning and plating lines. Transfer of the barrels on these lines is by means of overhead hoists.

Automatic Plating Plant

The automatic plant has sixteen tanks and a hot-air drying chamber. Each of the cleaning tanks is of 500 gallons capacity while the plating tank, located at a loop, holds 2,000 gallons of solution. Loading and unloading stations occupy the loop at the other end. The tank sequence is as follows :

1. Hot alkaline degrease at 160—180 deg. F.
2. Running cold water rinse.
3. Warm 65 per cent hydrochloric acid pickle at 60—70 deg. F.
4. Cold water rinse.
5. Warm 15 per cent sulphuric acid at 60—70 deg. F.
6. Cold water rinse.
7. Hot 15 per cent sulphuric acid at 160—180 deg. F.
8. Cold water rinse.
9. "Klenewel" cyanide carbonate electrolytic polish.
10. "Zyntax" plating solution at 90—100 deg. F.
11. Cold water rinse.
12. Cold water rinse.
13. 0·5 per cent nitric acid brightener.
14. Cold water rinse.
15. Cold water rinse.
16. Hot water rinse.

Fumes are continuously collected and delivered, by way of a duct running under the tanks, to a scrubber before being exhausted. The waste liquor is neutralized by lime and ferrous-sulphate before discharge to the drains.

Each of the two tracks carries fifty plating jigs. These are, of course, detachable and a variety of patterns are used to suit the different types of work being treated. The average capacity is 30 items per jig. Components take 38 minutes to complete the cycle ; 8·25 minutes being spent in the plating tank. Depth of coating is varied between 0·0003 in and 0·005 in by control of the current density. No attempt is made to group the work according to size or area. Work is progressed as it comes to hand.

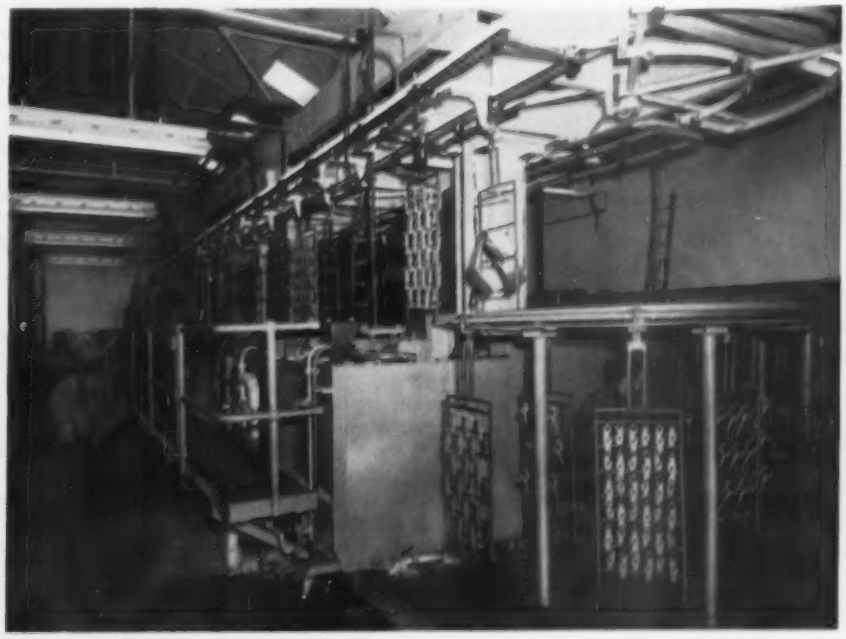
The plant is operated at an average current density of approximately 50 amp/ft² and about 1 cwt of zinc is deposited each week. Solutions are heated by steam coils and temperatures may be boosted by electric heaters. All cleaning solutions are changed monthly. The plating solution is continuously passed through a filter press at 25 lb/in² pressure.

Barrel Plating

On the barrel plating lines the total cycle time is from 40 to 45 minutes. Here screws, bolts, nuts, washers and many other small items are plated at a charge rate of 90—100 lb per barrel. On the cleaning line the work is loaded into a metal barrel and progressed through four tanks for degreasing, cold water rinse, hydrochloric acid pickle and cold water rinse. At the end of the line the metal barrel is emptied into a chute pivoted in a cyanide rinse tank. From this chute the parts are poured into an ebonite barrel, standing on a cradle, which is then transferred by overhead hoist to the plating tank in the parallel return line.

The average time in the plating tank is 15 minutes and rotation is at 17 r.p.m. Current density ranges from 75 to 100 amp/ft² at 10 volts. After a cold rinse the parts are poured into a drain skip and then transferred to an enclosed centrifugal dryer running in hot air.

A substantial proportion of the firm's production is regularly delivered by road to the vehicle manufacturer's plant. In some instances components are loaded directly into the truck or van and in others they are stacked in transport boxes. Considerable use is made, however, of pallets for transport. The system can speed up the loading and unloading of the transport vehicle and facilitate the stacking and transfer of the components at their destination.



The Efco-Udylite automatic plating plant operates on a total time cycle of 38 minutes. One hundred plating jigs are carried on two tracks

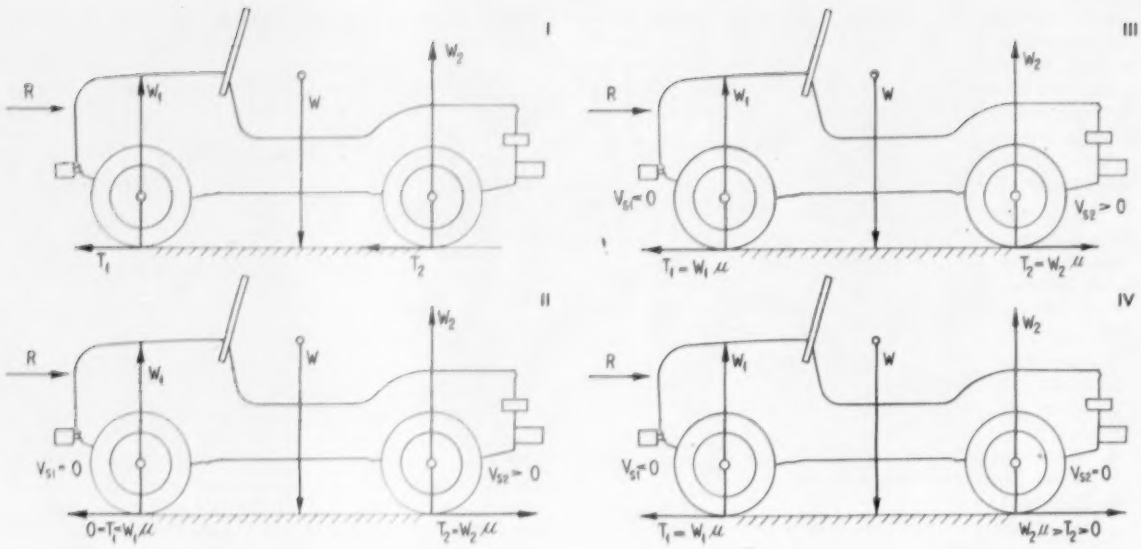


Fig. 1. Effect of tractive resistance on tractive effort of a vehicle with four-wheel drive and with the front wheels larger than those at the rear

FOUR-WHEEL DRIVE

An Analysis of the Mechanics of Four-Wheel Drive Under Straight Running Conditions

J. L. KOFFMAN, Dipl. Ing., M.I.Loco.E., and A. V. CARTER, B.Sc.(Eng.)

IN a four-wheel drive vehicle, unless three differential units are incorporated, the problem of driving all the wheels simultaneously is similar to that encountered with metal-forming machines when two rolls are employed to form the same strip. If the rolls are not exactly of the same diameter a differential action will result and impose tension or compression upon the strip, according to the direction of motion. For a vehicle, the simplest case is that of two pairs of wheels with rigidly coupled axles. The wheels will rotate with the same angular velocity ω, even though the diameter of the front wheels is larger than that of the rear wheels. If the axle loads are assumed to be identical, the vertical reactions at the wheels are:

$$W_1 = W_2 = W/2$$

where W is the load, and the suffix 1 refers to the front wheels and 2 to the rear wheels. Provided the coefficient of adhesion μ is identical throughout:

$$W_1\mu = W_2\mu = T/2$$

where T is the horizontal reaction at the wheels, Fig. 1.

If the vehicle is in motion and the front wheels are larger in diameter than the rear ones and are rolling without slip, the smaller wheels must slip and the force $\mu W/2$, applied at the point of contact between the rear wheels and the road, will oppose the vehicle motion. The resultant tractive resistance, comprising the external and internal, or parasitic, resistance, is:

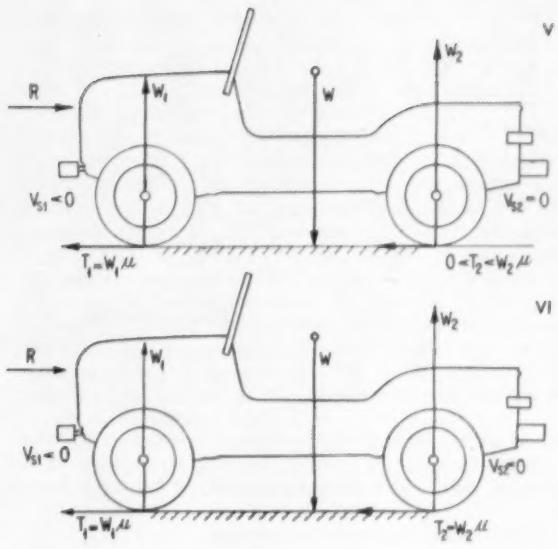
$$R = 2\,(T/2) + \mu W/2$$

where $T = T_1 + T_2$, and $\mu W/2$ acts in the direction of the motion of the vehicle. Thus the forces that depend on adhesion cancel out, making the development of a tractive effort theoretically impossible as long as μ remains the same at all four wheels. However, in practice the larger wheels are likely to roll and spin and the smaller ones to roll. The resultant useful reaction force due to adhesion is in the direction of motion and is equal to the tractive resistance. The transmission components connecting both axles are stressed by the torque required to spin or slip one set of wheels, as well as by the driving torque; and, although the resultant stresses might be high, the power loss due to the parasitic resistance will not be great because of the small relative rotational displacement between the two sets of wheels. It is important to note that the stresses on the interaxle drive components may bear no relation to the torque developed by the engine.

When analysing the forces experienced under operating conditions it is desirable to make certain simplifying assumptions. Thus, no allowance will be made for the tangential deformation of the tyres which might under certain circumstances result in an alteration in the original difference of tyre diameters of the coupled axles, nor will account be taken of the rolling resistance, the effect of weight transfer, or the effect of the magnitude and direction of the transmitted torque on the effective wheel radius. The general mode of wheel motion depends upon the forward speed, the rotational velocity and the effective wheel radius. If v is the forward speed, r the wheel radius and ω the rotational velocity, the general equations of wheel motion are:

$v = \omega r$ pure rolling
$v > \omega r$ wheels slip and roll
$\omega = O$ pure slipping (or standstill)
$v < \omega r$ wheels spin and roll
$v = O$ pure spinning (or standstill)

Then, if the circumferential velocity v_s of the wheel relative to the road is assumed positive when its direction is the same as that of the vehicle velocity, v, that is, the wheels are slipping as the vehicle moves forward, the general



Diagrams V and VI of Fig. 1, on the left

equation is:

$$v = \omega r + v_s$$

Consequently:

$v_s = O$	pure rolling
$v_s = v - \omega r$	simultaneous rolling and slipping ($v_s > O$)
$v_s = v$	pure slipping ($\omega = O$)
$v_s = \omega r - v$	simultaneous rolling and spinning ($v_s < O$)
$v_s = \omega r$	pure spinning ($v = O$)

For a four-wheel drive arrangement without a third differential, $\omega_1 = \omega_2$ and

$$\omega_1 r_1 + v_{s1} = \omega_2 r_2 + v_{s2}$$

or,

$$v_{s2} - v_{s1} = \omega_r (r_1 - r_2)$$

The last equation confirms that if $r_1 \neq r_2$, relative displacement between tyres and road occurs since $v_{s2} - v_{s1} \neq O$. If the front wheels are larger than those at the rear, that is $r_1 > r_2$, the velocity of slip relative to the road is greater for the rear wheels, $v_{s2} > v_{s1}$. So, if the front wheels roll without slipping or spinning, that is, $v_{s1} = O$, then the rear wheels slip and $v_{s2} > O$. But if the front wheels are spinning whilst rolling forward, $v_{s1} < O$, then it is possible for the smaller rear wheels to roll and at the same time slip, $v_{s2} > O$, or spin, $v_{s2} < O$, or simply to maintain pure rolling in which case $v_s = O$. It should be noted that, provided that the loads are identical and the coefficient of adhesion remains the same for all four wheels, it is not possible for the smaller wheels to spin whilst the larger ones are either rolling or slipping, nor is it possible for the larger wheels to slip when the smaller ones are rolling, or rolling and spinning.

Now, the effect of tractive resistance on the magnitude and distribution of the tractive effort developed at the wheels will be considered, where $r_1 > r_2$. If T_1 and T_2 are the wheel reaction forces and R the tractive resistance less the rolling resistance, and if the horizontal forces are in equilibrium,

$$T_1 + T_2 = R$$

while $T_{1max} = W_1\mu$ and $T_{2max} = W_2\mu$

The tractive resistance can be as much as:

$$R_{max} = W_1\mu + W_2\mu$$

If the tractive resistance is smaller than R_{max}, then:

$$T_1 + T_2 < W_1\mu + W_2\mu$$

However, the tractive effort developed by one set of wheels cannot be smaller than the relevant T_{max}, otherwise both sets of wheels will roll without spinning or slipping, which is impossible so long as $r_1 \neq r_2$.

In Fig. 1 (II), the front wheels, which are larger than the rear ones, are rolling without slipping or spinning, whilst the rear wheels are slipping so that:

$$R + W_2\mu = T_1$$

$$O < R + W_2\mu < W_1\mu$$

or,

$$-W_2\mu < R < (T_1 - T_2) \quad \ldots\ldots(1)$$

The value of T_1 increases with R and the front wheels begin to spin as soon as $T_1 = W_1\mu$ (Fig. 1 (III)), this condition being attained when:

$$R = (W_1 - W_2)\mu \quad \ldots\ldots(2)$$

The conditions (1) and (2) apply only if R is negative, that is, if the vehicle is on tow or running downhill.

As the resistance R increases still further, the spinning of the rear wheels gradually decreases and ultimately stops altogether[1]. At the same time the value of T_2, which acts in a direction opposite to the vehicle motion, is gradually reduced from its maximum value to zero. The braking effort of the slipping rear wheels gradually diminishes throughout this range. This condition will apply so long as:

$$(W_1 - W_2)\mu < R < W_1\mu \quad \ldots\ldots(3)$$

As soon as T_2 is reduced to zero:

$$R = W_1\mu \quad \ldots\ldots(4)$$

A further increase of tractive resistance will cause T_2 to change its direction, Fig. 1 (V), so that it acts in the direction of motion of the vehicle. This condition is limited by:

$$W_1\mu < R < (W_1 + W_2)\mu \quad \ldots\ldots(5)$$

The maximum value of R is limited by the spinning of the wheels, Fig. 1 (VI), while the possible modes of wheel motion are summarized in the accompanying Table.

Generally $W_2 > W_1$ and therefore $r_1 > r_2$. In these circumstances, the third case in the table may apply, and the values of R may be positive as well as negative. In general, the torque distribution of a four-wheel drive vehicle with $r_1 > r_2$ is represented by the third, fourth or fifth case, the smaller rear wheels rolling and possibly slipping, while the larger front wheels roll and possible spin. The tractive effort developed at the rear wheels will vary within the limits of:

$$T_2 < -W_2\mu \text{ and } T_2 < W_2\mu$$

according to the magnitude of R.

In the third case, the tangential reaction at the rear wheels opposes the forward motion of the vehicle, Fig. 2, its value

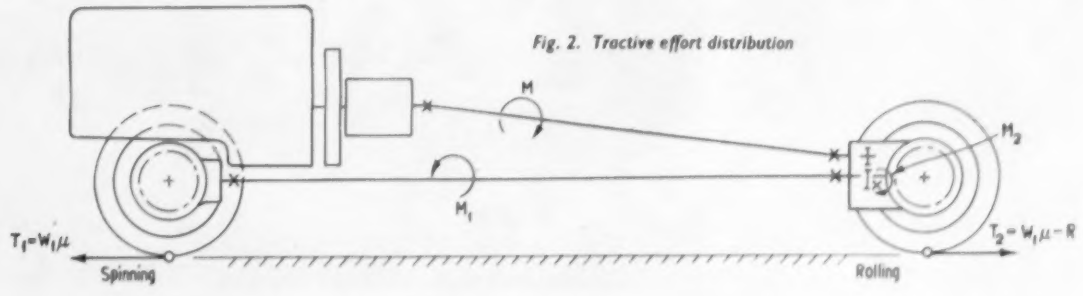


Fig. 2. Tractive effort distribution

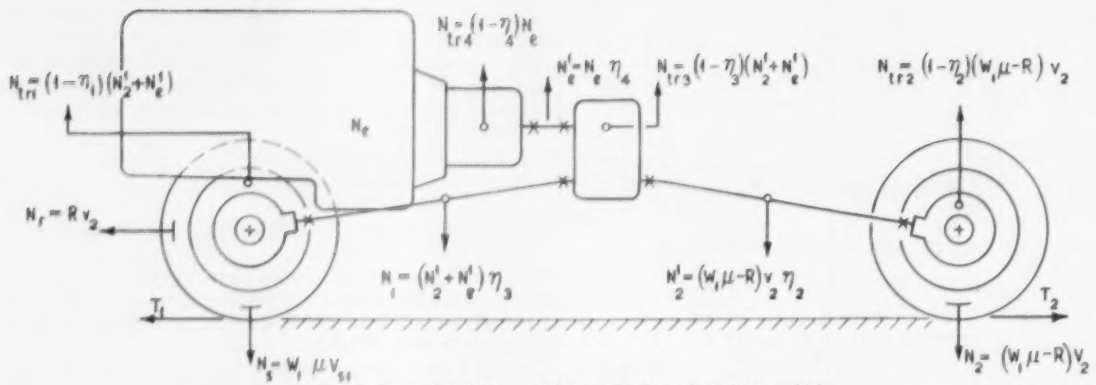


Fig. 3. Power distribution and losses of a four-wheel driven vehicle

being $T_2=W_1\mu-R$, and the torque due to T_2 stresses the cardan shaft driving the front wheels, owing to power circulation between the front and rear wheels. The torque in the shaft driving the rear wheels is:

$$M_2=(W_1\mu-R)\,r_2\,\eta_2/i$$

where η_2 is the efficiency of the rear axle drive and i its gear ratio. If a torque M is developed at the gearbox output shaft and there is a direct drive through the transfer box, the torque transmitted by the shaft driving the front wheels is:

$$M_1=(M+M_2)\eta_3$$

where η_3 is the efficiency of the transfer gears. Thus, the torque imposed on the front-wheel drive depends on that developed at the rear wheels, as well as upon the engine torque, whilst a number of subsidiary factors affect the power availability at the wheels. In the case under consideration, the vehicle speed is:

$$v=v_2=\pi r_2\,n/30$$

while the peripheral velocity of the slightly spinning front wheels is:

$$v_1=\pi r_1\,n/30$$

so that the relative velocity of the slightly spinning front wheels is:

$$V_{s1}=v_1-v_2$$
$$=V_2\,(r_1-r_2)/r_2$$

The power developed by the engine, Fig. 3, is:

$$N_w=N_r+N_s+N_{tr}$$

where N_r is the power output required to overcome the total tractive resistance, N_s the power lost due to the spinning of the front wheels and N_{tr} the power losses in the transmission components, that is, the gearbox, the transfer box and the axles. The power transmitted to the rear wheels is

$$N_2=(W_1\mu-R)\,v_2$$

while the losses due to the rear axle are:

$$N_{tr2}=(1-\eta_2)N_2$$

The power transmitted from the rear axle to the transfer box is:

$$N'_2=N_2\eta_2$$

The gearbox losses are:

$$N_{tr4}=(1-\eta_4)N_e$$

and the power transmitted from the gearbox to the transfer box:

$$N'_e=N_2\eta_2$$

The losses in the transfer box are:

$$N_{tr3}=(1-\eta_3)\,(N'_2+N'_e)$$
$$=(1-\eta_3)\,[(W_1\mu-R)\,v_2\eta_2+N_e\eta_4]$$

The power available at the front axle drive is:

$$N_1=(N'_2+N'_e)\eta_3$$

while the losses due to this component are:

$$N_{tr1}=(1-\eta_1)(N'_2+N'_e)\eta_3$$
$$=(1-\eta_1)\,[(W_1\mu-R)\,v_2\eta_2+N_e\eta_4]\eta_3$$

The total transmission losses are:

$$N_{tr}=N_{tr1}+N_{tr2}+N_{tr3}+N_{tr4}$$

which, by introducing the appropriate values, are expressed by:

$$N_{tr}=(W_1\mu-R)(1-\eta_1\eta_2\eta_3)\,v_2+N_e(1-\eta_1\eta_3\eta_4)$$

If $N_r=Rv_2$, $N_s=W_1\mu v_{s1}$ and N_{tr} are given by the above

Fig. 4. Torque-measuring, axle extension shaft installation on the vehicle

Fig. 5. The power pack and amplifier are carried on the rear seat, the pen recorder is mounted on a shelf next to the steering wheel and the fifth-wheel speedometer is between the front seats

equation, the power balance of the vehicle is:

$$N_e = Rv_2 + W_1\mu\, v_{s1} + (W_1\mu - R)(1-\eta_1\eta_2\eta_3)\ v_2 + N_e (1-\eta_1\eta_2\eta_3)$$

Since $v_{s1} = v_1 - v_2$, this equation can be rewritten:

$$N_e\,\eta_1\eta_2\eta_4\eta_c = W_1\mu\, v_1 - (W_1\mu - R)\, v_2\,\eta_1\eta_2\eta_3\eta_c$$

Thus, the engine power available at the wheels in this particular case is equal to the output from the slipping rear wheels through the transmission to the front wheels. The second negative value on the right-hand side of the last equation imposes an additional torque on the transmisison components concerned, but does not add to the torque required to overcome the tractive resistance. Because of this, it might be referred to as the parasitic torque: it is transmitted from the front wheels through the road to the rear wheels. This circulation of power causes losses in the transmission components connecting both axles. These losses become smaller as the tractive resistance increases and are zero when $R = W_1\mu$.

If the various component efficiencies considered in the above equation are assumed to have the following values[3]:

$\eta_1 = \eta_2 = 0{\cdot}95$	axle drive efficiency
$\eta_3 = 0{\cdot}96$	transfer drive efficiency
$\eta_4 = 0{\cdot}955$	transmission efficiency in all gears, except direct, with input and output shafts not in line
$\eta_4 = 0{\cdot}94$	transmission efficiency in all gears, except direct, with input and output shafts in line
$\eta_4 = 0{\cdot}97$	transmission efficiency in direct gear, with running intermediate shaft
$\eta_4 = 0{\cdot}985$	transmission efficiency in direct gear, with intermediate shaft stationary
$\eta_c = 0{\cdot}993$	cardan shaft efficiency.

The equation becomes:

$$N_e = [W_1\mu\, v_1 - (W_1\mu - R)\, v_2 \times 0{\cdot}88]\ 1/(375 \times 0{\cdot}873)$$

where W is in lb, v in m.p.h., and R in lb. The constant 1/375 is introduced since $N_e = Tv/375$, where T is the tractive effort in lb.

To determine the magnitude of the forces acting on the transmission components of a four-wheel drive vehicle, tests were carried out at the Fighting Vehicles Research and Development Establishment, F.V.R.D.E., of the Ministry of Supply. The vehicle used was a 4 cwt, 4×4 truck, FV1800. The civilian version of this vehicle, the Austin Champ, has been described in detail previously[3], and the main difference between the civilian and military versions is that the A90 engine is installed in the former, whereas the Rolls-Royce W.D. B80, four-cylinder engine is employed in the FV1800.

In place of the driving hubs, extension shafts were fitted between the half shafts and wheels, (Fig. 4). These extension shafts were fitted with 2,500 ohm resistance strain gauges, the signals from which were led through slip ring assemblies on the shafts to a Kelvin and Hughes four-channel pen recorder, Fig. 5. Also carried in the vehicle were four six-volt batteries in series, driving a rotary transformer to supply 240 volts A.C. to the recording instruments.

The power unit incorporated a mains transformer and smoothing components providing 220 volts D.C. for the amplifier and oscillator high tension supply, 450 volts D.C. for the recorder timing and pen writing, 15 volts A.C. for the recorder heaters and motor, and 6·3 volts A.C. for the amplifier and oscillator heaters. It also incorporated a 2 Kc/s oscillator which was fed to the bridge circuits. The amplifier unit comprised four bridges with input transformers, four amplifiers including demodulator and output stages, and a valve voltmeter. Each bridge was fitted with balance controls and calibration switches, by means of which known values of resistance could be introduced into one arm. The recorder unit contained a magnet and coil assembly,

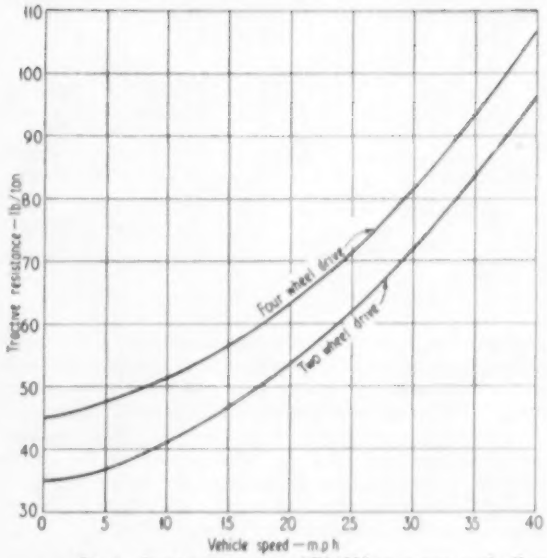


Fig. 6. Tractive resistance of FV 1800 on tarmac road. Tyre pressure 20 lb/in² on all four wheels
Four-wheel drive: $R = 45 + 0{\cdot}25V + 0{\cdot}95A + 0{\cdot}26(V/10)^2$
$A = 13$ ft
Two-wheel drive: $R = 35 + 0{\cdot}25V + 0{\cdot}95A + 0{\cdot}26(V/10)^2$

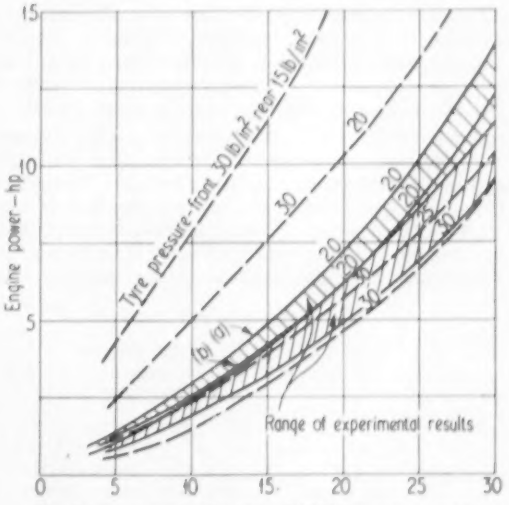


Fig. 7. Power required to drive FV 1800 on tarmac road
(a) Standard vehicle, four-wheel drive
(b) Two-wheel drive

a paper drive system and a timing unit. Between its poles the magnet carried four stiffly suspended moving coil units with a stylus arm connected to each. Teledeltos dry recording paper was drawn under these stylus points by a motor and reduction gearing. Current passes from the pens through the paper, and causes black trace to be drawn.

When "centre zero" balanced, the coil units had a maximum deflection of ±7·5 mm. The frequency response was uniform within 12 per cent from zero to 80 c/sec. Phase shift was closely proportional to frequency between zero and 80 c/sec and was 90 deg at about 70 c/sec. An oscillator and a cold cathode discharge tube circuit in the timing unit generated short, high voltage pulses at a rate of 40 per second. These pulses were fed to one or more fixed pens accurately providing rows of timing dots along each edge of the record. Before the tests, the extension shafts and recording instruments were calibrated with a hydraulic torsion test machine.

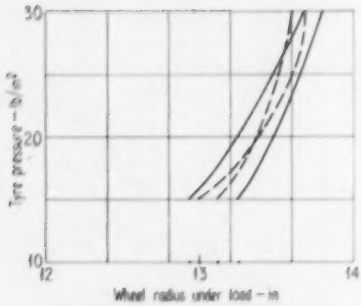


Fig. 8. Effect of pressure on tyre radius of FV 1800
——— *Front wheels*
– – – *Rear wheels*

When the vehicle carried the necessary instruments, batteries, rotary transformers, driver and observer, the loads on the front and rear wheels were 0·875 and 1 ton respectively. The tractive resistance of the vehicle was determined by evaluating the results of running-out trials, on lines described elsewhere[4], and the relevant data for the vehicle running on smooth level tarmac road are shown in Fig. 6. In Fig. 7, the power required to drive the vehicle is plotted, assuming an overall mechanical efficiency of 0·875.

These tests were carried out on the F.V.R.D.E. test track, the speed of the vehicle being maintained as nearly constant as possible, on hand throttle settings, at 5, 10, 15, 20, 25 and 30 m.p.h. Once the speed, as indicated by a speedometer operated from a fifth wheel, was reasonably constant, the recorder was switched on; then, after a few seconds, the front-wheel drive was disconnected without altering the vehicle speed. Thus it was possible to record the torque at each wheel and also to observe the change of torque distribution when changing from four- to two-wheel drive.

To ascertain the effect of wheel radius on torque magnitude and distribution, the tests were carried out with the tyre pressure of the front wheels constant at 30 lb/in², whilst that of the rear wheels was reduced, in steps of 5 lb/in², from 30 to 15 lb/in². These tests were further extended to cover the condition with the rear tyres at 30 lb/in², while the pressure of the front ones was reduced in steps, as before.

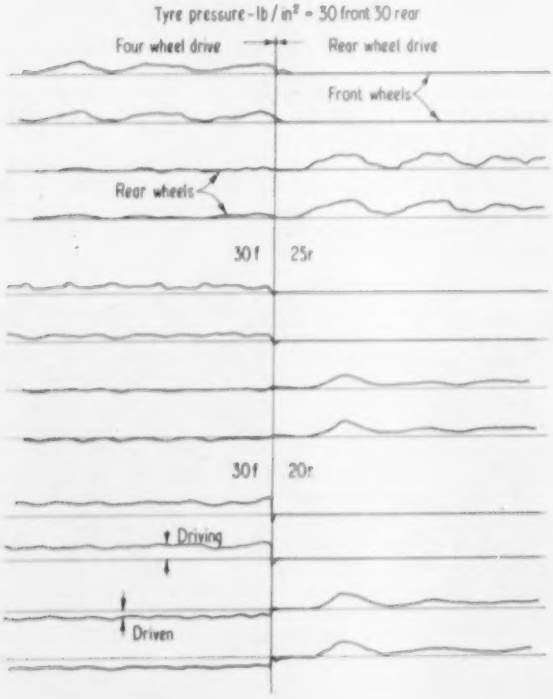


Fig. 9. Typical tractive effort records, as measured with a drive extension and strain gauges. The record moves from right to left and the front-wheel drive was disengaged without altering speed or throttle setting

The radii of the tyre in the static condition were measured and the results plotted in Fig. 8.

As shown by typical records, Fig. 9, the torque does not remain steady for a sufficient length of time to enable accurate measurements to be made, and because of this, no claim can be made with regard to the accuracy of subsequent evaluations. The results plotted in Fig. 10 show that with the larger wheels at the front, the rear wheels resisted the vehicle motion until their tyre pressure was increased to 25 lb/in² when, because of the increased values of the tractive resistance R, they began to develop a positive torque at speeds in excess of about 20 m.p.h. Both sets of wheels develop a positive torque when the tyre pressure is increased to 30 lb/in². The total torque developed at the wheels, as represented by the algebraic sum of the recorded values, Fig. 11, is reduced as the rear tyre pressure and the vehicle speed increase. Similar trends are shown in Figs. 12 and 13, which represent the conditions encountered with a constant pressure in the rear tyres. However, it must be stressed that the torque employed to propel the vehicle is represented by the positive values in Figs. 10 and 12, the negative values showing the magnitude of the resistance imposed by wheel slip. In Fig. 7, the positive torque values of Fig. 10 are replotted in terms of engine h.p., assuming an overall transmission efficiency of 0·875.

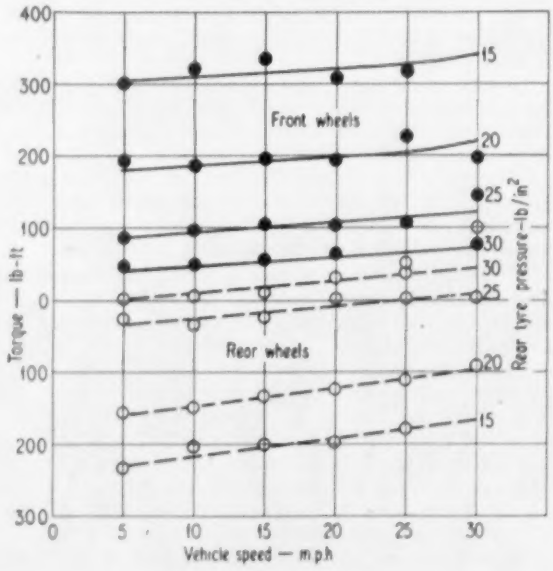
Tractive resistance values for tyre pressures of 30/25 and 30/30 lb/in² are lower than those plotted in Fig. 6. This is because the curves in Fig. 6 embrace the highest values of numerous tests. It is of interest to compare these results with those obtained on the basis of theoretical considerations. For example, when $v_1 = 15{\cdot}3$ m.p.h., $v_2 = 15$ m.p.h., so that if $W_1 = 1{,}960$ lb and $\mu = 0{\cdot}8$:

$$N_e = [1{,}960 \times 0{\cdot}8 \times 15{\cdot}3 - (1{,}960 \times 0{\cdot}8 - 1{\cdot}875 \times 56{\cdot}2) \times 15 \times 0{\cdot}88]1/327 = 14{\cdot}2 \text{ h.p.}$$

as compared with 11·5 h.p. of Fig. 7. The difference between the theoretical and actual values might be due to the alteration of the effective wheel radii as a result of torque application and the consequent reduction of the difference between v_1 and v_2.

From these results it can be seen that whilst a tyre pressure

Fig. 10. Below: torque developed at the wheels, with the front tyre pressure constantly at 30 lb/in² during the tests



difference of up to 5 lb/in² between the front and rear wheels might be tolerated, a greater difference appreciably increases the propulsion resistance, fuel consumption and rate of wear of components. However, it should be stressed that the parasitic losses causing this increase in power absorption will be reduced as the tractive resistance increases, and although the power demands will not be reduced, they will be due to the actual tractive resistance encountered by the vehicle instead of to an internal resistance in the transmission.

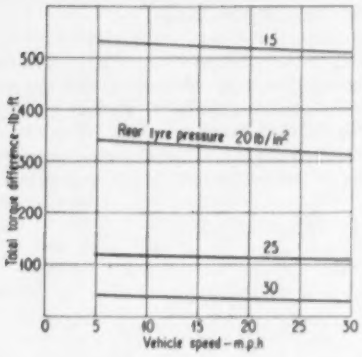


Fig. 11. Left: wind-up torque between the front and rear axle, with the front tyre pressure constant at 30 lb/in²

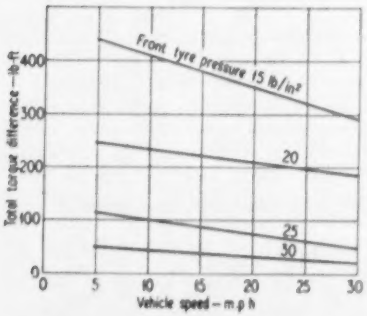


Fig. 13. Wind-up torque between axles, with the rear tyre pressure constant at 30 lb/in²

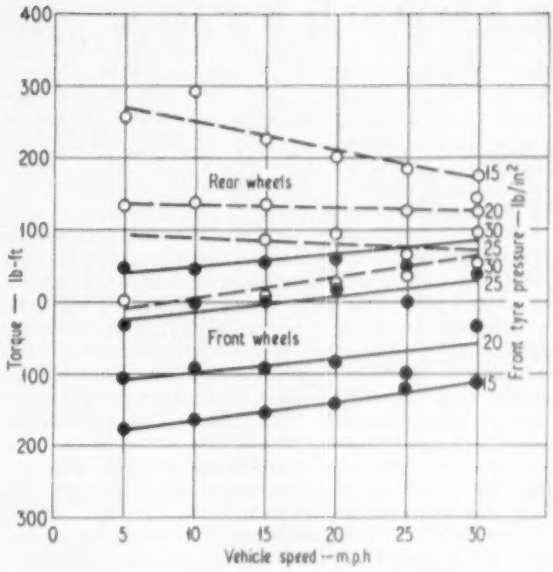


Fig. 12. Right: torque developed at the wheels, with the rear tyre pressure constant at 30 lb/in²

The algebraic sum of front and rear wheel torques, Fig. 11, is that imposed on the cardan shaft driving the front wheels. although the values are considerably in excess of those required to drive the vehicle, their magnitudes are limited by axle load and the coefficient of adhesion. With this type of vehicle, the four-wheel drive is used, for example, for towing heavy loads or running across country; in these circumstances, the tractive resistance will be mostly of a high order, so the parasitic torques and losses will be small.

Similar considerations apply to 6×4 and 6×6 trucks. However, the conditions are more complicated since, if $r_1 > r_2 > r_3$: all wheels might spin; the wheels of the first and second axle might spin and those of the third axle roll; the wheels of the first and second might spin whilst those of the third axle might slip; the first axle might spin and the second and third slip; the first axle might roll, and the second and third slip; or, all wheels might slip. With these arrangements it is advisable to be particularly careful in ensuring that the tyre diameters are as near identical as possible by maintaining accurately the correct pressures. Provision of a third differential is scarcely justified as a general requirement.

Effects of four-wheel drive on vehicle stability have not been considered yet, but it is hoped to rectify this omission at some future date. The authors wish to express their indebtedness to Mr. D. F. Pooley for the valuable assistance rendered throughout the tests. Figs. 4 and 5 are Crown copyright reserved, reproduced with the permission of the Controller, H.M.S.O.

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Equation	Fig. No.	Wheel motion		Tractive effort		Tractive resistance
		Front	Rear	Front wheels	Rear wheels	
1	1 (II)	Rolling	Slipping	$O < T_1 < W_1\mu$ With motion	$T_2 = W_2\mu$ Against motion	$-W_2\mu < R < (W_1 - W_2)\mu$
2	1 (III)	Spinning	Slipping	$T_1 = W_1\mu$ With motion	$T_2 = W_2\mu$ Against motion	$R = (W_1 - W_2)\mu$
3	1 (IV)	Spinning	Rolling	$T_1 = W_1\mu$ With motion	$W_2\mu > T_2 > O$ Against motion	$(W_1 - W_2)\mu < R < W_1\mu$
4	1 (IV)	Spinning	Rolling	$T_1 = W_1\mu$ With motion	$T_2 = O$	$R = W_1\mu$
5	1 (IV)	Spinning	Rolling	$T_1 = W_1\mu$ With motion	$O < T_2 < W_2\mu$ With motion	$W_1\mu < R < (W_1 + W_2)\mu$
6	1 (VI)	Spinning	Spinning	$T_1 = W_1\mu$ With motion	$T_2 = W_2\mu$ With motion	$R = (W_1 + W_2)\mu$

CARBURATION AND FUEL SYSTEMS

A Discussion of Current Problems and Practice

Charles H. Fisher, M.I.Mech.E., M.S.A.E.

THERE are few aspects of the automobile which engender greater interest than carburation, and few which create more discussion. In this paper, however, the author has widened the field to cover more of the fuel system, and has dealt with some of the factors which react upon it. Nevertheless, although the carburettor is only one component of the fuel system it is still the most important. There are some who believe that the wider adoption of petrol injection is imminent, but it is most likely that for low and medium priced vehicles, the carburettor will be employed for many years to come. Petrol injection was used on some of the very early motor cars, and it is interesting to envisage events had petrol injection become the standard method of fuel metering and delivery, and the carburettor appeared at the present time, in its present form. One can imagine the carburettor being hailed as the greatest invention of all time, for its relative cheapness and simplicity. There is no doubt that viewed in relation with these two factors the carburettor does do a remarkable job in metering the fuel in the correct proportions to the air according to engine demand and producing the working mixture, all within quite narrow production limits of fuel flow. Fuels also have their place in the picture, and alterations to their constituents and characteristics can have most pronounced effects upon the functioning of the fuel system.

There are at the present time two different types of carburettor produced in this country, namely, the open-choke and the constant-vacuum varieties. In America and on the Continent the open-choke pattern is universal, but in Great Britain both kinds are used. In this paper the discussion of the various aspects of fuel system problems apply in the main to both varieties of metering instrument. The great majority of open-choke carburettors produced are downdraught, while all the constant vacuum instruments are side-draught or horizontal. These are mounted either in the horizontal position or tilted slightly to what has become known as the "semi-downdraught" position.

Downdraught carburettors created quite a sensation when they first appeared on American cars in 1929. In 1930 the first production downdraught installations in this country were pioneered by Humber Ltd., when models introduced by that concern were so equipped as standard. That is a long time ago, and there must be a generation which cannot remember the time when all carburettors were either side-draught horizontal or vertical up-draught.

Shorter Downdraught Carburettors

One of the most pressing fuel system problems in motor-cars of present design arises from the adoption of lower bonnet-lines which leave less room for the accommodation of the carburettor and air silencer. It is natural that the first thought should be towards horizontal carburettors, but this is not such an easy way out as it first appears. Horizontal carburettors, with their attendant air silencer or air cleaner attachments, can take up a lot of side room, and the wing valance members do not leave much space in this direction either. Again, most motor vehicle designers of large scale production models favour the downdraught instrument. Large numbers of engines are thus designed for down-draught carburettors, and to redesign for horizontal installations would present a major change.

Carburettor designers are therefore turning their thoughts towards much shorter downdraught carburettors, and much ingenuity is being shown in telescoping the various components of the carburettor into one another in the endeavour to have the shortest possible height. Theoretically, the longer carburettor should be the more satisfactory, in that venturi forms of the maximum length can be em-

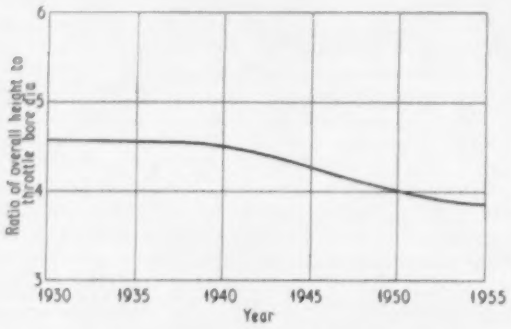


Fig. 1. Trend in shorter downdraught carburettors

ployed and so promote the greatest pressure recovery. But experience gained up to the present indicates that the shorter carburettor performs very well. Fig. 1 illustrates the existing trend towards shorter downdraught carburettors, where the ratio of the over-all height to the diameter of the throttle barrel is plotted against years. This is not to state that some short carburettors were not produced before the present necessity arose, but they were the exceptions.

It would appear that the best method of combating the present low bonnet line style is to incline the engine in the chassis after the fashion of the Mercedes 300 SL. Down-draught carburettors of normal length could then be employed. In addition, this scheme should provide excellent fitting, and where the hemi-spherical combustion chamber is used, should result in better cooling of the exhaust valve, because the valve is then in the direct gravitional path of the incoming mixture stream.

Carburettor icing

There is of course nothing new in carburettor icing. It was experienced in a minor form on early motorcars, but with the long unheated induction systems then in use it is astonishing that icing troubles were not much more widespread. In the past, carburettor icing has presented a most serious problem in aircraft operation, and many fatalities were attributed to this cause. During the last 20 years, however, various methods have been devised to overcome the trouble, and in normal circumstances icing on aircraft is not a serious problem to-day. With road vehicles, however, carburettor icing can be most annoying, but it is not dangerous in anything like the same degree. There must be a large number of drivers who have experienced this phenomenom and complained bitterly about the inconvenience caused by it, but yet are probably quite unaware of

Based on a paper read before the Institution of Mechanical Engineers, Automobile Division, London, 13th December 1955.

the real cause. The first indication of icing troubles since the war came in reports from America, when icing became prominent following the introduction of premium fuel in that country. During the winter of 1953-54, however, it began to be experienced in this country, following the introduction of premium fuel over here. It is doubtless associated with the higher volatility of these fuels.

In its simplest and most widely experienced form, carburettor icing results in persistent stalling of the engine in traffic and at traffic lights, particularly during the warm-up period, before the engine has attained its normal working temperature. Drivers in the country who can continue to drive through the warm-up period up to running temperature without frequent stops seldom encounter this phenomenom. Many drivers have been puzzled by this condition, because on some days (when icing conditions are not critical) no stalling occurs, and the weather need not necessarily be cold for the trouble to arise. In the States, where the cars are almost fully automatic, having automatic chokes and automatic transmission and lacking any hand control of the fast idle during warm-up, the trouble is of course aggravated. Experience in this country indicates that different makes of cars vary a good deal in their response to icing conditions. Some are certainly more prone to icing than others. This is doubtless a function of the amount of heat picked up by the ingoing air and by the carburettor itself.

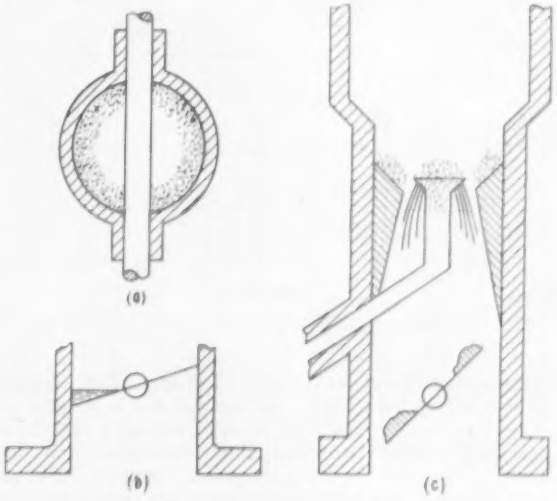
Contrary to common supposition, carburettor icing does not require very cold weather for its promotion. Critical icing conditions generally occur between 30 and 60 deg. F., with a high factor of atmospheric humidity. Most experimental work carried out indicates that the greatest icing severity is encountered at atmospheric temperatures of about 40 deg. F., with relative humidity of 100 per cent. It is interesting at this stage to examine icing conditions encountered in aircraft operation. Ice is usually present in two forms, known as refrigeration ice, and impact ice. Refrigeration ice is caused by the cooling effect of the evaporating fuel as it leaves the spraying orifice and strikes the sides of the venturi, throttle valve and other metering elements. The drop in temperature can be considerable, as much as 40 to 70 deg. F., and this can cause freezing of practically all the moisture present in the ingoing air. Expansion of the air across the venturi and the throttle valve still further increases the fall in temperature. With a high factor of atmospheric humidity the moisture in the air is deposited and frozen on the adjacent metal elements, and ice builds up thereon and so throttles the passage of mixture into the engine, reducing the power output, possibly to dangerous limits. It has been found that the rate of ice accretion is roughly proportional to the rate of water drawn in with the charge, and that the smaller the droplet size the faster the rate of ice accretion. At one time carburettor icing with its resulting falling off in power was the cause of a number of aircraft fatalities, but for many years means have been provided to ensure that ice accretion is kept to a minimum.

Impact ice is the term applied to the formation of ice along the leading edges of the wings and to most exposed edges of the aircraft, including the air entry to the carburettor or injector, and the protuding elements therein. It is caused by the deposition and freezing of water droplets or semi-plastic particles of ice which freez when they encounter cooled surfaces. Impact ice has been reported with air temperatures as low as —40 deg. F[1]., which indicates that water droplets can exist in a highly cooled state even at this low temperature. Throttle ice has been reported with air temperatures of —37 deg. F[2]. According to Hare,[3] it is possible for both liquid water and ice to exist in the air between +32 and —40 deg. F., when at a given temperature the saturation vapour content has one value for water and another for ice, so that within this band there may be two values for saturation. In operating motor vehicles in Alaska[4] severe icing with its attendant stalling has been experienced with air temperatures in the region of —60 deg. F., where in conditions of ice fog, humidity can be of the order of 80 per cent. These are extreme conditions for ground level temperatures, and it is unlikely that many vehicles will have to be operated under such circumstances.

Winter temperatures in Great Britain are comparatively mild. The lowest official temperature recorded is —17 deg. F. at Braemar in Scotland[5] (1895). A lower figure but an unofficial one is recorded for Blackadder in Berwickshire of —23 deg. F. (1879). Verkhoyansk in Siberia holds the world official record for low temperature with —93·6 deg. F., although the American astronomer Heuer quotes —108 deg. F. at Oimekon, Siberia. It will be recalled that Capt Scott recorded —108 deg. F. at the Ross Sea in 1911. There is no doubt that the chief difficulty likely to be encountered when operating vehicles at such low temperatures would be in cold starting.

Throttle Ice

This is the most common form of icing experienced in road vehicle operation, resulting in erratic idling and persistent stalling, particularly when the vehicle is driven through traffic during the warm-up period from cold. The ice builds up on the throttle valve plate and occasionally on the adjacent walls of the throttle body, closing off the idling gap around the edge of the throttle valve so that stall results. Although the trouble is most prevalent during warm-up, it can occur when the engine is at normal running temperature,



a Throttle ice formation b Melted c Main spray ice

Fig. 2. Throttle and main spray ice

if the atmospheric temperature and humidity are within the critical band.

In one set of experiments conducted by the author last winter the car was driven a distance of ten miles, by which time the engine has reached its running temperature. The car was then taken on the MIRA track and driven at a steady speed of 35 m.p.h. for two miles. When the car was brought to a stop the engine stalled. The air silencer was loosened so that it could be lifted off quickly and the run repeated; the engine again stalled when the car stopped. The bonnet was lifted and the air silencer quickly removed. Ice could clearly be seen, formed in a ring around the outer top top face of the throttle valve. Further tests over a distance of five miles at the same speed showed a considerable

increase in ice accretion. Fig. 2a shows how the ice forms first in a ring around the outer edge of the theottle valve, and then extends over the whole surface, having the appearance of thick hoar frost. The ice melted rapidly when the engine was stopped. It formed a pool of water in the angle between the throttle valve face and the wall of the throttle body, Fig. 2a. In this instance, icing was eliminated completely by blanking off the lower half of the radiator. The atmospheric temperature during the tests was 38 deg. F.

It has been common practice with aircraft float carburettors to jacket the throttle body with hot oil, and to pass hot oil through a hollow throttle valve and spindle. This is a most expensive procedure, however, and one which would be quite impossible on road vehicles. Clothier,[6] in his experiments on aircraft carburettor icing, found that with no heating of the throttle body, ice formed on the inner walls of the throttle body and eventually joined that formed on the throttle valve. In road vehicle carburettors a good deal of heat is transmitted to the throttle body from the induction manifold flange, and this doubtless hinders any considerable ice accretion at this point. Induction manifold designs vary a good deal, but it is possible that the thermostatically controlled hot spot, in which the exhaust gases are directed away from the riser junction at normal running temperature, might account for some ice formation under these conditions.

It has been found that the temperature of the throttle valve itself is lowest at small throttle opening, when the whole area of the plate is being sprayed by fuel as the main

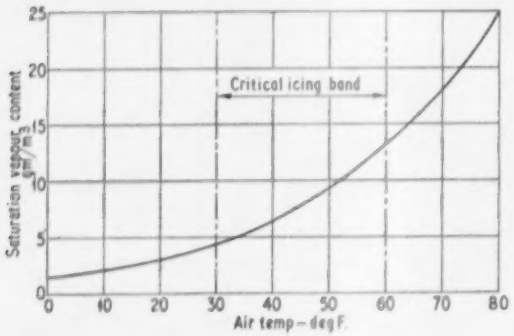


Fig. 3. Curve of absolute humidity

spray system comes into action. The area of the throttle plate receiving the spraying fuel becomes less as the throttle is opened, until at wide open throttle the greater part of the fuel spray is passing either side of the throttle valve, so that much of it misses the valve altogether. When the throttle is closed to the point where the main spray system dies out, the temperature of the throttle valve will rise. With carburettors of the open choke variety or the constant vacuum type with a separate idle system discharging on the engine side of the throttle, the throttle valve will then be free of fuel spray from either source, because the idle discharge orifice is located in the engine side of the valve. On constant vacuum instruments having no separate idle system, the valve will be sprayed during this period of running also because even the idling spray must pass the throttle valve.

In their investigations into road vehicle throttle ice, Dugan and Toulman[4] found that throttle valve temperatures can lie between 14 deg. and 29 deg. F., and that those with the lowest temperatures are most prone to warm-up stalling. However, in another set of experiments Kunc, Hickock and Haworth[7] established the fact that on some vehicles throttle valve temperatures can be as low as 7 deg. F. It is possible to raise the temperature of the throttle valve by various means, some of which are described later in this paper. That fuel volatility is a factor in throttle icing has been proved by Dugan and Toulman,[4] where a change of fuel from high volatility to low volatility resulted in the rise in throttle valve temperature of 20 deg. F.

Main Spray Ice

This form of icing is less common, but when it does occur it is more troublesome than throttle ice. Main spray ice in a minor form can cause irregular running and poor petrol consumption. In its worst condition the ice builds up around the main spray system, Fig. 2c, blocking the main air passage, causing severe loss of power, and eventual stoppage of the vehicle. This can be most confusing to the layman driver. During the few minutes it takes to lift the bonnet, examine the sparking plug leads, etc., the ice will have melted, and the engine starts and runs perfectly. The driver starts off again, puzzling what can have happened, and when the car has covered a sufficient distance the trouble starts all over again.

Main spray ice is caused by the spray system and surrounding metering elements losing heat faster than it can be replaced from the body of the carburettor or by the incoming air. Rodgers and Brook[8] came to the conclusion that in aircraft operation main spray icing will occur if the temperature of the metering elements falls to a figure of 5 deg. F. below the dewpoint of the atmosphere. Most carburettors are designed to avoid undue heat losses, and metering elements are kept out of the fuel spray as much as possible, with good thermal paths through which heat lost by ice formation can be replaced. All things indicate that given sufficiently severs atmospheric conditions, and ice-prone fuel and other factors conducive to ice accretion, both varieties of carburettor will permit ice formation.

The greatest atmospheric factor in carburettor icing is humidity. It does not have to be a cold day for icing to occur, and we have observed that the critical temparture band lies between 30 and 60 deg. F. Humidity may be expressed in a number of ways, the most common expression being that of relative humidity. This term has been defined by Hare[9] as the "meteorological equivalent of absolute humbug," but within the comparatively small range of temperatures likely to be encountered in icing it doubtless serves as well as any other. The term humidity refers to the amount of water vapour present in the atmosphere at any given time. During the evaporation of water into the air evaporation continues until no more moisture can be absorbed. This condition is known as the saturation vapour content, and is entirely dependent upon the tempature of the air. Cold air contains very little moisture, hot air a great deal. The capacity of the air for sustaining moisture increases with increasing temperture, and at a much greater rate.

This is illustraetd in Fig. 3, where the actual mass of vapour per unit volume of air (absolute humidity) is given over a range of temperatures. This curve clearly illustrates the difference in the amount of moisture sustained by the atmosphere over the band of temperatures likely to be encountered in Great Britain, particularly over the icing-prone band. Above 60 deg. F. although there is a large amount of moisture present the temperature is rising above the critical for ice accretion. Below 30 deg. F., while the temperature is low, there is too little moisture in the atmosphere to cause trouble. We must not overlook that fact, however, that in the temperature range between 32 deg. and —60 deg. F. icing can be encountered by reason of the abnormal condition of twin saturation vapour content phenomenom mentioned earlier in this paper. Yet another factor intrudes to complicate the situation. During the evaporation of the fuel, water will be condensed, and the latent heat of the vapour will be added to the mixture.

Thus, the drop in temperature will be less on a damp day than on a dry one, which is rather the reverse of what might be expected. On the one hand therefore we have humidity promoting ice accretion by the introduction of water vapour at critical temperature and on the other humidity retarding it by the release of latent heat. The borderline is thus a narrow one. Icing seldom occurs with humidity less than

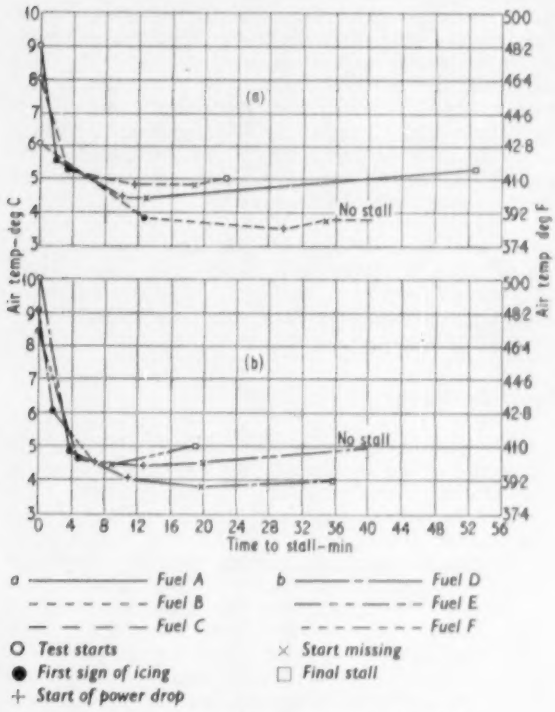


Fig. 4. Icing characteristics of some modern premium fuels

60 per cent. Clothier, in his investigations into carburettor ice on aircraft, came to the conclusion that it is necessary to reduce the humidity to something of the order of 50 per cent in order to prevent ice accretion. With an air intake temperature of 59 deg. F., an increase of 21 deg. was required for this purpose.

Icing appears to be prevalent on the Atlantic seaboard of America, where, according to Alden, extremes are reached when humidity is in the region of 100 per cent. Stalling due to throttle ice is then such that warm-up stalling is universal, that is, it applies to nearly all cars and nearly all fuels. Although we in this country often experience these atmospheric conditions, we do not appear to suffer stalling in such severity, or we should hear more about it.

It appears most probable that fuel volatility plays a large part in ice accretion. Holaday and Heath[9] have reported that stalling can be prevented (*a*) using impractical fuels of low volatility, and (*b*) it can be aggravated by going to similar extremes with high volatility fuels. Taylor and Gibson[10] found also that in experiments on 14 cars, all gave an excellent warm-up performance on a fuel having an ASTM point of 180 deg. F., at atmospheric temperatues between —7 and 37 deg. F. But when seven of these cars were operated at atmospheric temperatures of 35 to 50 deg. F., six gave trouble with stalling and poor idling, but were satisfactory with less volatile fuels. Holaday and Heath made some similar experiments, using 27 cars, with two fuels of different volatility. All 27 cars ran satsifactorily with low volatiltiy fuels, but with high volatility fuel 21 gave unsatisfactory perfoamances, and nearly all the complaints were of stalling, generally during warm-up.

As a result of tests carried out by Dugan and Toulman,[4] it was found that increasing the temperature of the 10 per cent point reduced stalling on engines prone to warm-up stall, but had no effect on those free from this complaint. Increasing the temperature of the 50 per cent point showed still greater improvement on the stalling engines but no effect upon the remainder. Increasing the 90 per cent point indicated less effect on any of the engines tested, but a very slight improvement on those engines prone to stall.

What palliatives are possible to combat carburettor icing? In America, where the trouble is confined chiefly to throttle ice with its attendent stalling, several manufacturers have gone to the length of heating the throttle body by means of a jacket cast round a portion of the body, through which exhaust gas or hot coolant is passed. Some trouble has been experienced with the exhaust-heated jacket, through the gases attacking the metal and causing porosity around the idle channels. While the coolant-heated throttle body would not suffer in this manner, it could introduce service complications, because the coolant would have to be drained in order to remove the carburettor for service reasons. There are several other objections to heating the carburettor in this manner, chief among which are vapour troubles in hot weather. The general tendency in this country is to keep the carburettor reasonably cool, but some compromise is necessary from the icing aspect. Another scheme mentioned by Dugan and Toulman is to employ a short separate

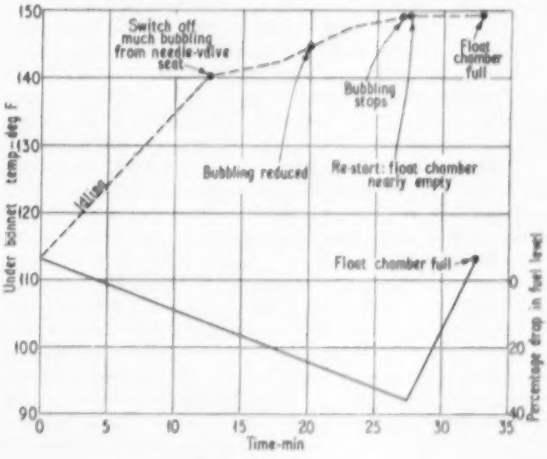


Fig. 5. Fuel pump percolation

throttle body of aluminium, and so provide a rapid passage of heat to the throttle valve during warm-up.

In the work with which the author has been associated it has been proved that simple throttle ice can be cured by partially blanking off the lower half of the radiator. Much depends upon where the air intake for the air silencer is located. There are instances where throttle icing has occurred when the air intake is placed low down at the front of the engine, so that the air inspired is cool. It would be a comparatively simple matter to arrange a two-way air duct, with a plain flap valve so placed to feed to the engine either cool air from the front of the bonnet space or warm air from the region of the exhaust manifold, according to seasonal conditions. Such a device is employed on the Fiat 600. Experiments in this country have indicated that with an air temperature of 40 deg. F. and high humidity, it

was necessary to raise the temperature of the ingoing air some 20 deg. F. to prevent ice accretion of the main spray system.

Anti-icing additives in the fuel

Although premium fuels were in widespread use in Great Britain before 1939, it was not until the year 1953 that premium fuels were again available. During the winter of 1953-1954 a great deal of carburettor icing was experienced by the motoring public, and it was after this period that fuels began to be marketed containing additives which were claimed to prevent icing. The fuels were all of premium grade, and were found to vary a good deal in their capacity to inhibit ice accretion. Figs. 4*a* and 4*b* show the results of some investigations carried out by D. Hodkin, R. C. Smith and R. Syson. In previous work it had been established that the road speed on the particular engine on test giving the most repetitive icing was 27 m.p.h. steady speed, and these conditions were reproduced on the dynamometer. In order to evaluate the characteristics of the various fuels under test a schedule was arranged, and all tests were made in exactly the same manner. Stop watch times were taken (1) from the setting of the required speed and load conditions to (2) the first appearance of icing, (3) first indication of power drop, (4) first misfiring of the engine, and (5) the final stall. Six different fuels were tested, and were given the symbols A, B, C, D, E, F. The only reason for plotting the results on two separate graphs was to avoid the confusion of too many lines. It will be seen that fuels A, C and F lie close together at the first point (1), but that they differ a good deal in their final stall points. Fuels B and F, although both showed early power drop and misfiring, did not ice up badly enough to stall the engine. Fuel A exhibited power drop and misfiring fairly early in the test, but ran for 53 minutes before stalling. On the other hand, fuels C, D and E stalled comparatively early. These experiments were carried out on the test bed, and the air feeding the engine was passed through a cooling system specially developed for the purpose, which maintained the ingoing air at a temperature of 36 deg. F., with 100 per cent humidity.

It had already been established[7] that carburettor icing could be prevented by the inclusion in the fuel of small quantities of suitable additives. In this report three additives were mentioned, and are given the symbols X, Y and Z. On the car tested, 14 stalls were recorded, using standard fuel with no additive. With 2 per cent of additive X, one stall was recorded, with 1 per cent of additive Y, one stall also, and with 0.5 per cent of additive Z, stalling was eliminated. An interesting item of this report is the fact that no difference in icing severity was observed between carburettors fitted with hand strangler systems or automatic chokes. While the constituents of the additives were not disclosed, it is known that isopropyl alcohol is one additive which discourages ice accretion.

Hot starting and percolation

These troubles come at the other end of the temperature scale, and are due to the light ends of the fuel (incorporated in the spirit to provide easy cold starting) boiling in hot weather. Difficult hot starting in summer is often believed to be due to percolation in the carburettor itself, resulting in fuel being ejected from the discharge orifice and producing a rich mixture. In the experience of the author this seldom occurs. A much more common condition is that the fuel in the engine driven fuel pump boils, and the consequent pressure forces the carburettor float needle off its seat, so raising the fuel level and causing flooding. In some circumstances difficult hot starting may also be caused by a weak mixture, where the fuel in the fuel pump and carburettor has boiled away. Time can be an important factor here, and there are in fact a number of variables to be considered. It is worth while to examine some of these :

1. (*a*) In cases where the carburettor is mounted on an exhaust-heated induction manifold with insufficient heat insulation of the carburettor, the fuel feed to the idle system may become hot enough to vaporise the fuel therein, so that there is no liquid fuel left to supply the idle system.

(*b*) Where the engine driven fuel pump gets too hot, the fuel therein may boil and generate enough pressure to force the needle of its seat and so flood the manifold.

(*c*) Another factor, associated with the above, is the boiling of the fuel in the fuel pump and fuel line, generating

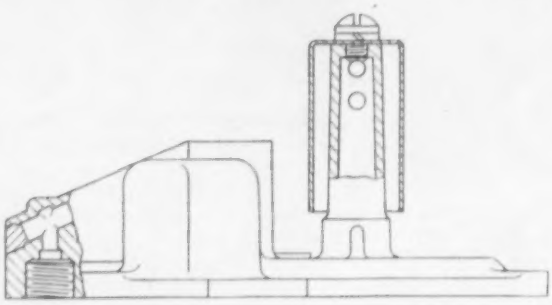


Fig. 6. Float chamber vent dust cap

a large quantity of vapour (whose only outlet is past the needle seat of the carburettor), for which the area of the float chamber vent provides insufficient release. This aspect is considered further in the section dealing with float chamber venting.

2. In more extreme circumstances, where the components become hotter still, the factors involved become more complicated. These conditions were often encountered in tank operation during the war. On switching off the engine in hot weather, the fuel would boil in the fuel pump, fuel line and carburettor, and in the early stages re-starting would be difficult owing to richness. After about one hour, however, the situation was reversed. By that time the fuel from these components had boiled away, being vented either into the air intake and induction system, or into the atmosphere, according to the carburettor venting system employed. With internal venting, starting would be difficult owing to the excess of rich vapour present in the induction system ; while with external venting the mixture would be

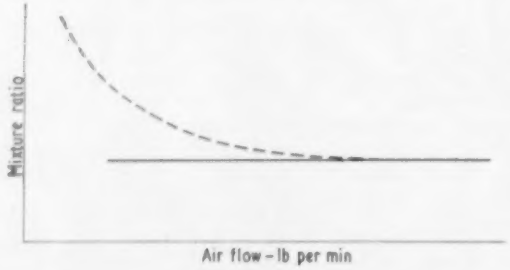


Fig. 7. Characteristic curve of non-economizer carburettor

weak, owing to the fuel line being empty and the vapour having been vented to atmosphere.

Fig. 5 shows some interesting curves from some tests during the developemnt of a road vehicle with which the author was associated. The bonnet of the car was fitted with a perspex observation window, directly above the carburettor. The tests were made during a hot summer day, the car being run for ten miles fast driving. The car

was then stopped, the bonnet lifted, the air silencer and carburettor float chamber quickly removed, and the bonnet replaced. The engine was then idled in the sun for 12 minutes. When the engine was switched off a fountain of liquid fuel and vapour bubbles arose from the needle valve seat indicating fuel boiling in the engine driven pump and fuel line. After 20 minutes bubbling gradually ceased when the under-bonnet temperature had risen to 140 deg. F. By this time the fuel level in the carburettor had fallen by 36 per cent owing to evaporation. The engine started in three sec on the little fuel left at the bottom of the float chamber, but idling continued for four minutes before the float chamber was full, proving that the fuel pump had virtually boiled dry. Subsequent development work eliminated this trouble. The changes included altering the run of the fuel line, with careful screening on the fuel pump and filter, etc., by means of asbestos shields. Subsequent hot starting tests in the Swiss Alps resulted in trouble-free starting in every instance.

In the above tests the carburettor was vented to atmosphere, having two 3.6 mm. diameter holes drilled in the vent stack. In subsequent tests carried out on the same day with the float chamber cover in position, these holes

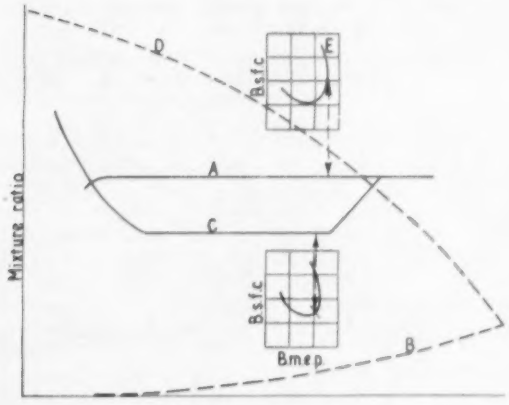


Fig. 8. Mixture ratio and loops, economizer carburettor

were found to be inadequate for the release of all the vapour generated in the fuel pump and fuel line. After idling in the sun for 20 minutes and then standing for four minutes with the engine stopped, some drops of fuel were observed from the main discharge orifice. The venting was then increased by drilling two extra 3.6 mm. diameter holes in the vent stack, and the test was repeated. There was then no discharge from the orifice, indicating that the discharge had been due to vapour pressure within the float chamber and that the extra vent holes had provided the necessary area to release the pressure.

In order to avoid vapour troubles in hot weather it is necessary to keep the fuel system cool, without going to extremes which will introduce icing troubles in winter. To this end the following items can be enumerated :

(1) See that the run of the fuel line, from fuel tank to fuel pump and from fuel pump to carburettor is as remote as possible from radiated or conducted heat.

(2) Make sure that there is no restriction on the suction side of the fuel pump, for restriction will increase the pressure drop and encourage vapour formation.

(3) If the fuel pump is of the engine-driven variety it must be heat insulated as much as possible and shielded where necessary. The best position for the fuel pump of this kind is on the side of the engine remote from the exhaust manifolds, and towards the lower front of the engine.

(4) Where a fuel filter is employed, this should be placed in a cool spot, and shielded if necessary.

(5) Little latitude is possible in the location of the carburettor, but this component should receive the same attention. A heat insulating gasket between the carburettor and the induction manifold flange is effective, together with an asbestos shield to protect the float chamber from radiated heat, particularly with induction systems embodying an exhaust heated hot spot. Where the throttle body of the carburettor is separate from the main body a gasket can be interposed between the two. In such instances the throttle body may be permitted to run warmer as a precaution against icing.

Float chamber venting

Float chamber venting can be either external (to atmosphere) or internal (into the air intake). In most instances the venting is external. This system provides an uninterrupted passage for the escape of vapour generated in the fuel pump, fuel line and float chamber, while at the same time this arrangement does permit the best metering characteristics, particularly on four cylinder engines. The internal vent system has the advantage of making the entire carburation system dust proof, but it has the disadvantage of venting all the vapour generated in the fuel system during hot weather into the induction manifold. While many American carburation systems are designed with internal venting, some have been observed where external drillings have been made in the channels to provide an atmospheric vent, which indicates that the American encounter the same problems that we do.

One method which has given satisfactory service in a particularly dust-laden district, while retaining the benefits of atmospheric venting, is illustrated in Fig. 6. In this case the float chamber vent orifices are placed in the sides of the vent stack as shown. The modification consists of a long metal cap, which fits over the stack and is secured by a screw at the top. This device effectively masks the vent holes from fan and other draughts likely to carry dust, while leaving the holes unobstructed. Somewhat contrary to expectations, reports coming back from this area over the last few years have been most favourable. Indeed, it is reported that the float chamber remained virtually free from from dust even under extreme conditions where the air intake of the air cleaner was continually being obstructed. But whether the venting employed is internal or external, the area of the orifices must be sufficitnly large to release all the vapour likely to be generated in the fuel system, otherwise the float chamber will be pressurized, with subsequent ejection of fuel into the induction system.

Part throttle economy

Carburettors below the size of 30 mm. throttle barrel diameter are usually simple static instruments, and have no automatic economy system incorporated. The mixture ratio curve of such a carburettor is illustrated in Fig. 7 where the part-throttle curve (dotted line) is seen to lie very close to that of the full-throttle (solid line). On the larger sizes of carburettor, however, an economy system is usually included, and the resulting mixture ratio curve is shown in Fig. 8. Here, the curves A and B are those of full throttle and part-throttle respectively, D being the manifold depression curve relating to curve C and B a similar curve relating to curve A. Above and below are two mixture loops, for full-throttle and part-throttle respectively. There would of course be more of these loops, spaced along the full and part throttle curves, but they are omitted to avoid confusion. There are various methods of running part

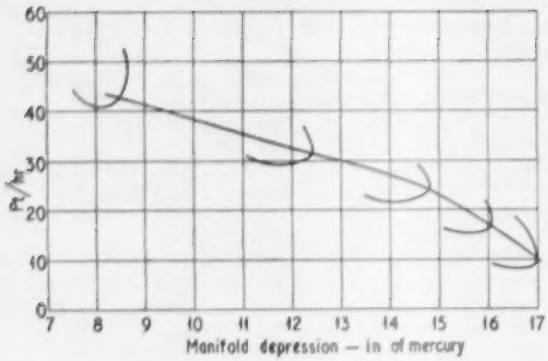


Fig. 9. Road load mixture loops and manifold depressions

throttle mixture loop tests, and the method usually followed by the author is illustrated in Fug. 9, where the fuel consumption either in pph or B.S.F.C. is plotted against manifold depression.

A general picture of economy action is shown in Fig. 10. The engine on which the tests were carried out was a large four-cylinder power unit, and throughout the test the throttle was fixed at a point some 10 per cent short of the wide open position. After the part throttle economy mixture setting had been determined, readings were taken with the power jet open and closed, the r.p.m. being adjusted to the required figure in each instance. The curves clearly show the necessity for economy action, if maximum power is to be retained. With the power jet closed to the part throttle economy position, there was a loss of power of 12 per cent. On the other hand, if the mixture was adjusted for maximum power (power jet open), the part throttle fuel consumption was excessive. The range of economy action in this instance was rather more than can always be usefully employed on four-cylinder engines.

The position of the chosen point on the mixture loop is of course dependent upon the capacity of the engine to burn weak mixtures. Care must be exercised against the temptation of selecting too low a point on the loop, for allowance must always be made for production tolerances in the carburettor and the engine, and also for winter operation in cold weather. In cold winter weather the mixture metered will be some 4 per cent weaker than in summer, owing to the increased density of the air charge. In addition, evaporation will be slower, and should the fixed jet setting be too close to the "weakest maintained," the carburation will be unstable in cold weather. The difference in carburation "feel" with changes in atmospheric temperature has to be experienced to be believed. Weaker mixtures can be accepted in cold weather if the under-bonnet temperature can be kept up, and it is a pity that the modern bonnet grill does not lend itself easily to the use of the radiator muff, which performs a most useful function in maintaining a higher under-bonnet temperature. There is also much to be said for the radiator blind, and it is a pity that the thermostatically controlled radiator shutter has gone out of fashion. In past years a number of cars were so equipped, but at the present time the Rolls-Royce seems to be the sole survivor.

Carburettor flow limits

It is general practice for a production carburettor to be manufactured with a tolerance of fuel flow, usually of the order plus or minus 3 or 4 per cent. There is often a good deal of misconception about carburettor fuel flow tolerances. The general idea seems to be that while carburettors on engine test will vary in fuel flow between one carburettor and another, engines do not vary in the same degree. Actually, nothing is further from the truth, and it has been established that in testing a single carburettor on a number of identical production engines of the same type, the tolerance of fuel flow can be wider than that permitted of the carburettor. Some results of these tests are illustrated in Fig. 11, where 10 production engines were tested with the same carburettor, on the same test bed and using the same recording instruments. A study of these curves shows it is obviously a waste of time attempting to hold carburettors to a rigid tolerance of fuel flow on engine test, for carburettors will be needlessly changed. A better idea would be to include an extra figure to cover engine variations as well.

Similarly, carburettors should not be rejected on engine test for failing to produce readings within some specific fuel consumption band. All the carburettor can respond to is the pressure drop imposed across it, it cannot recognise variations in engine power. An engine may not be giving its specified power, and although the carburettor may be within its pph band, it may well be outside a specific consumption band. It is the author's experience that carburettors which have failed to come within a specified pph band on test usually pass off satisfactorily when fitted to another engine.

Automatic chokes

Automatic chokes have always been a controversial

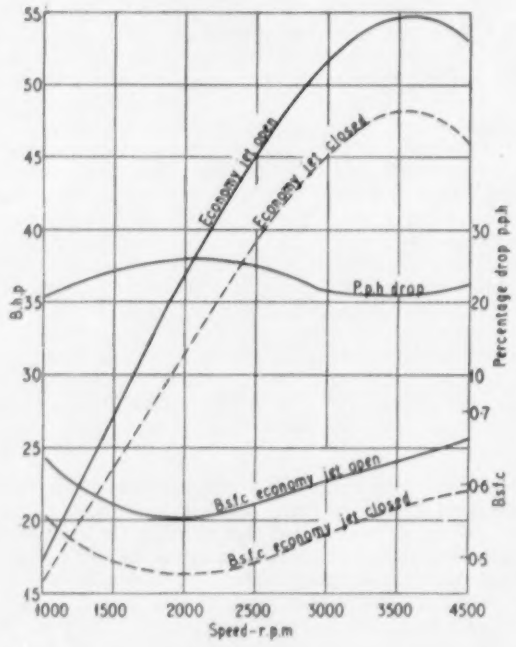


Fig. 10. Economizer characteristics

subject in this country, although this device is universally employed on American cars. This is probably accounted for by the fact that Americans like their cars to be fully automatic, and petrol consumption is not so important to them as it is to us. There is little doubt that on short journey work better petrol consumption can usually be obtained by manipulating the hand control than with an automatic choke, although the latter is an excellent cold starting device. On the other hand, there are those who argue that the layman driver is apt to pull out the hand strangler control for starting and then drive away and forget to push the control out of action.

All automatic choke systems of the strangler valve pattern

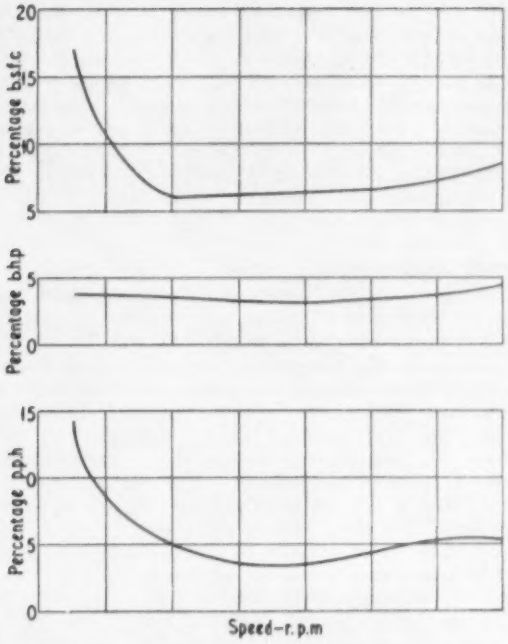
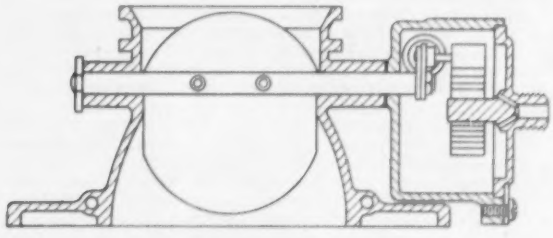


Fig. 11. Carburettor fuel flow variations between engines. Curves showing percentage difference in fuel flow, brake horsepower and brake specific fuel consumption in pints per hour

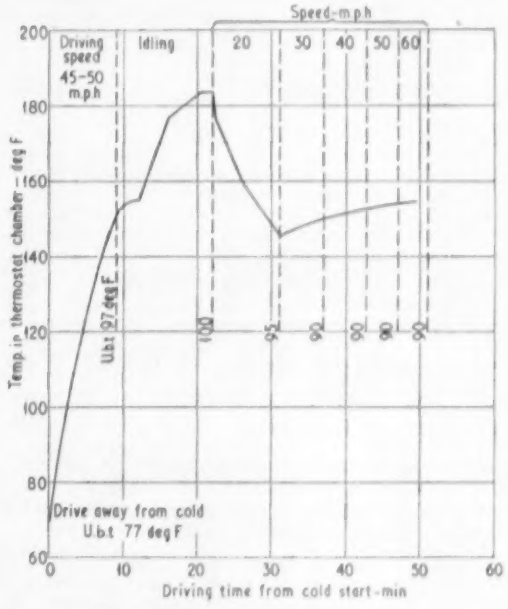
are based on the same scheme. Briefly, a coiled bi-metal thermostat spring, placed in a source of engine heat, is linked to the off-set mounted strangler valve in such a manner that when the engine is cold, the strangler valve is held closed under the influence of the spring. A suction piston is incorporated to open the strangler valve a predetermined amount as soon as the engine starts, and a fast idle arrangement is provided to keep the engine running at a reasonable speed and so prevent stalling while the engine is cool.

On most installations used in this country, the thermostat spring is housed in a recess cast in the exhaust manifold. Rolls-Royce, however, employ a similar recess cast in the coolant heated hot spot of the induction manifold. When in position, the spring fits into the recess in the manifold, with ample clearance, and the backing plate forms the cover. A rod with a light ball-joint end links the thermostat lever to that of the strangler spindle. A few years ago a slightly different system was introduced in the States, and in this scheme the thermostat spring is housed in a small circular box mounted on the outside of the carburettor adjacent to the end of the strangler spindle. Fig. 12. A small lever on the end of the spindle picks up the outer end of the spring, so that the long connecting rod necessary with the remote thermostat is despensed with. By means of suitable channels in the body of the carburettor and an external tube some ¼ in diameter, heated air is drawn from a "stove" on the

Fig. 12. Assembly of hot-air thermostat and strangler valve



exhaust manifold, over the spring and so into the engine, so providing the necessary heat factor. Here again, a suction piston and fast idle mechanism is incorporated in the device. While this arrangement possesses certain advantages it has one drawback, and one which so far has prevented its adoption in this country. Owing to the thermostat spring being remote from a heated mass such as the exhaust manifold, the spring cools off too rapidly, which results in the strangler valve closing while the engine is still hot. Recently a modification was made by mounting the thermostat spring on a fairly thick metal plate, in an attempt to delay the cooling of the spring. The author has pursued investigations further along these lines and has experimented with housing the thermostat spring in a circular metal chamber of thick metal, with a heat insulating annular air space between the outside of the thermostat chamber and the outer housing. The inner chamber is located in position by three metal pegs, spaced equidistantly. When the unit is assembled, the inner chamber is pressed on to a cork gasket, and cork rings are placed between the outer face of the thermostat chamber and the inner face of the outer chamber, which, when the whole assembly is tightened in position by the screws, seal off the inner chamber with a minimum of heat loss. The "stove" is a U-shaped length of ¼ in stainless steel tubing fitted inside the exhaust manifold and welded in position, with both ends projecting through the top of the manifold. A length of external



Ambient temperature 69 deg F
U.B.T. Under-bonnet temperature

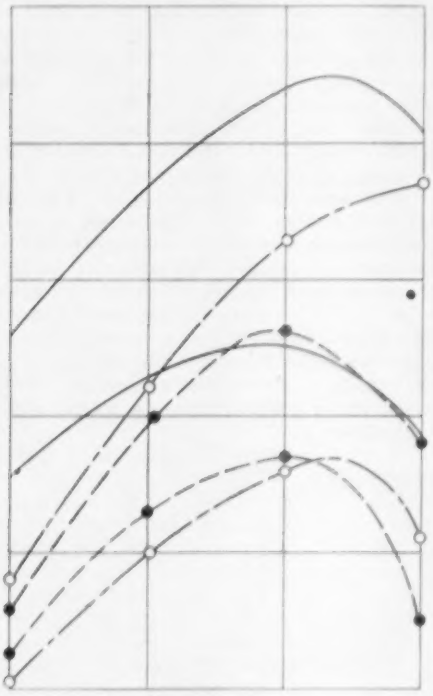
Fig. 13. Temperatures in thermostat chamber

tubing connects one end of the U-tube with the union on the thermostat chamber. Thermocouples were fitted into the thermostat chamber, and the air temperatures recorded are given in Fig. 13. Driving away from cold, the temperature rose in 10 minutes' driving to 154 deg. F., and this proved to be close to the average running temperature. Stopping the car and idling raised the temperature to 184 deg. F., which quickly dropped to 145–155 under normal driving. In winter conditions, from a cold start, the device came off fast idle to normal idle in 1.3 to 1.5 miles, which is considered satisfactory. If the fast idle is brought out of action too soon, there are the inevitable complaints of

stalling in traffic during warm-up, owing to the resistance of the cool engine oil, etc.

Test bed tuning and exhaust back pressure

The modern motor car is usually amazingly quiet, and much of this is due to the efficiency of the exhaust silencer. This quietness is obtained at a cost, however, and any silencer to be effective, must produce some back pressure.



——————— Power drop 14 per cent
Peak speed r.p.m. drop 10 per cent
— — — ○ Power drop 13 per cent
Peak speed r.p.m. drop 10 per cent
— - — - — - ● Power drop 8 per cent
Peak speed r.p.m. drop 3 per cent

Fig. 14. Curves of power losses from test bed to chassis exhaust systems

Figures as high as 5 and 6 lb. solidus in^2 are not unusual, and 3 lb.in^2 is a common value. This is not reflection upon the manufacturers of exhaust silencers, who have a difficult job to do. Back pressure does, however, affect the power delivered by the engine, and is a factor which should be considered when tuning the carburettor on the engine test bed. Test bed work is generally carried out using the test bed exhaust system, which is often little more than a large expansion box that produces very little back pressure. In some instances a large suction blower is employed, so that the engine exhausts into a pressure slightly lower than atmosphere. Such systems are excellent for investigating the power potential of an engine, so that losses in chassis exhaust systems can be evaluated. Fig. 14 illustrates some power curves of various engines, showing the loss sustained when chassis exhaust systems are fitted.

It will be noted how the back pressure drops the peak b.h.p., and in some cases the peak r.p.m. also. Both these factors affect the breathing of the engine, and a venturi size necessary for maximum power with an unrestricted exhaust may well be too large for the reduced power delivered under back pressure conditions. For this reason it would be more satisfactory if all development work carried out for road conditions should be done with the chassis exhaust system in position on the test bed. In laying out new test beds this is an aspect which should repay careful study. There are other factors in engine development which would benefit from this practice. Valve timing characteristic are often affected by the degree of exhaust back pressure imposed on the system. A combination of timing, lift and dwell which produces certain results with the test bed exhaust system can behave quite differently when subjected to a high factor of exhaust back pressure.

Future developemnst

Although it is always difficult to look far into the future, it does not appear as if there are any revolutionary developments in fuel systems which are likely to affect the medium and low power vehicle engines, at any rate for a good many years. Petrol injection is often quoted as a panacea for all fuel system problems, but it is not as simple as all that. From results of material already published in this country[11,12] there is little to indicate that a petrol injection system is likely to be produced in the near future which would produce as good results as the carburettor, *for the same cost*. It is more than probable that there will be a small field for petrol injection on racing engines, where it is necessary to obtain the maximum possible power from a given size of engine, regardless of cost. High powered sports cars of the more expensive kind afford another probability, as witness the Mercedes 300SL. But such an injection system would be an extremely expensive item. There is also a likelihood that this kind of fuel system may be adopted some of the larger and more expensive American V-8 engines, because with the V-8 engine the low bonnet line conflicts with the carburettor even more so than on the smaller in line engines. Again, the problems of applying petrol injection become more difficult as the power unit becomes smaller, and we must not confuse these massive American V-8 power units with our own small engines, on which the cost of the fuel system is a major item. There is, however, one project which is being watched with interest, and that is the Texaco Combustion Process. This is something more than mere petrol injection: it is almost a fresh cycle. But even should it become possible to employ it on the large American truck petrol engines, it is extremely doubtful whether the economics of the British motor inductry would permit it on the smaller engines common to Great Britain.

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Recent Publications

Brief Reviews of Current Technical Books

Kraftfahrtmechanik, Vol. I. (The Mechanics of Power-Driven Vehicles)

By Alfred Jante, in German.

Leipzig: B. G. Teubner Verlagsgesellshaft, Germany. 1955. 237 pp. Price 16.50 D.M.

Considering the number of engineers engaged in the design, development and manufacture of road vehicles, and also the fact that there is one power-driven vehicle for every 30 persons in the world, the paucity of scientific textbooks on automobile engineering is remarkable. This paucity is particularly disturbing when compared with the abundance of theoretical textbooks in such relatively new fields as gas turbine engineering and nuclear physics, as well as on older subjects, such as internal combustion engines. Although there are chairs in automobile engineering at many Continental and American universities and technical high schools, the number of advanced textbooks published in any one country can be counted on the fingers of one hand. Moreover, many of these books are mainly detailed descriptions of designs, whilst the fundamentals receive only scant attention. So this, the first of a two-volume treatise of the subject, by Alfred Jante, satisfies a long-felt need.

Alfred Jante is a distinguished designer and, in addition to occupying a chair at the Technical High School at Dresden, is also a director of the Internal Combustion Engine and Automobile Research Institute. He is widely known for his contributions in these fields and well qualified to deal with the subject. The work reflects the author's dual experience as a designer and teacher. Whilst rigorous and exact, it loses nothing in lucidity and freshness of outlook and to read it is both an education and a delight.

The author introduces the subject with a brief history of transportation and its mechanics. He then proceeds to analyse the mechanics of the traffic flow and their effect on vehicle design requirements, with particular reference to safety of operation. Particular reference is made to the relation between speed and the distance between vehicles. The problems are dealt with analytically, and the results presented in the form of curves and diagrams. Next, the author deals with vehicle dynamics. The dynamics of overtaking is considered in detail, with particular reference to overtaking at constant speed, with constant acceleration and retardation, and with linearly increasing acceleration and decreasing retardation with and without limited maximum speeds. The theoretical results are analysed on a comparative basis. Application of the various aspects of vehicle dynamics to the layout of road crossings, roundabouts, junctions and curves is discussed. Various graphic methods of vehicle performance estimation are illustrated, but this section would be improved by a few fully worked out examples, since they would enable engineers and students confronted for the first time with the various methods presented by the author to understand them more readily.

The important subject of vehicle kinetics occupies 128 pages. In it the author deals with tractive resistance determination by running-out tests. The tests and the method of evaluating the results are considered in detail, as also is the method of determination of resistance by running the vehicle down a slope. In both cases, the accuracy of the determination of the results would be improved by applying the method of statistical analysis due to Sauer and Pösch (Z.VDI, 1941).

All the components of tractive resistance are dealt with next. They include transmission losses and methods for their determination, and rolling resistance, with particular reference to losses due to tyres and gradients. Before turning his attention to air resistance, the author presents an unusually clear analysis of the relevant aspects of applied aerodynamics, and this is followed by data concerning the drag coefficients of representative vehicles. The effect of rotational masses on vehicle acceleration is dealt with next, and also some data on tractive resistance of lorries pulling trailers are given. Although the author concludes that the resistance is adequately represented by an equation of the form $R = a + bV^2$, extensive road tests both in this country and the United States indicate that it is more accurately expressed by $R = a + bV + cV^2$.

Having thus dealt with the sources of tractive resistance, the author turns his attention to prime movers. Tractive effort data is considered first, with particular reference to the method of presentation. This is followed by an analysis of typical petrol and diesel engine iso-b.h.p. and iso-fuel consumption curves. These considerations form the basis of a method of vehicle performance evaluation, using curves of tractive effort and fuel consumption plotted against speed; this clearly illustrates the importance of careful matching of such parameters as vehicle mass, resistance, gear ratio and engine fuel consumption characteristics. The book concludes with an analysis of vehicle performance development as "Mirrored by mechanics of motion". The bibliography embraces 86 references mostly of German origin; it is surprising that works such as Pirath's "Die Grundlagen der Verkehrswirtschaft", Berlin 1949, and Henry Watson's "Street Traffic Flow", London 1933, are not included.

The author has been most successful in presenting a much needed exposition of an important subject and we look forward to the appearance of the second volume. The publishers have done justice to the work in producing an attractive volume, copiously illustrated by diagrams, and it is offered at a reasonable price.

The Role of Petroleum in Modern Transport

London: The Institute of Petroleum, 26 Portland Place, W.1. 1955. 8¼ × 5½. 184 pp. Price 30s.

At the 1954 Summer Meeting of the Institute of Petroleum, nine papers were presented; these are published in full, together with a report of the discussions which followed each paper, in this volume. The work forms a comprehensive survey of fuel and lubrication problems relating to road, rail, air and sea transport. Two of the papers are of particular interest to automobile engineers. The first is entitled "Fuel Problems in Road Transport" by A. T. Wilford, B.Sc., A.R.C.S., F.R.I.C., of the London Transport Executive, and the second is "Lubrication Problems in Road Transport" by S. E. Holmes, A.R.I.C., and H. M. White, of C. C. Wakefield and Co. Ltd.

Automotive Fuel, Lubricating and Cooling Systems

By William H. Crouse

New York: McGraw-Hill Book Co., Inc. 1955. 9¼ × 5¼. 420 pp. Price 32s.

This is another of the McGraw-Hill series of the five books, covering in detail the construction, operation and maintenance of automobiles. Like the others, it is intended for the guidance of service mechanics. The first 290 pages of the book deal with the fuel systems, carburettors, injection systems and fuels. In the next 63 pages, engine lubricating systems and their servicing are covered. Cooling systems are discussed in the remaining 22 pages. Two appendices are included: one is on exhaust gas analysers and the other is a glossary of technical terms.

Hydraulische Pressen und Druckflüssigkeitsanlagen, Vol. II. (Hydraulic Presses and Equipment)

By Ernst Müller, in German.

Berlin: Springer-Verlag, Germany. 1955. 6¼ × 9¼. 278 pp. Price 39 D.M.

The spectacular developments in the field of aerodynamics and hydrodynamics and the resultant flood of technical literature on these subjects, have tended to eclipse the substantial advances that have been made in the hydrostatic field. This tendency is even more marked because the developments that have taken place in the science of hydrostatics lack the glamour of high speeds or enormous power outputs. However, the recent developments in connection with presses for sheet metal, forging presses, presses for bending armour-plate and extrusion presses are impressive and merit the comprehensive treatment given in this book, which explains and details the design principles, fields of application and methods of operation.

This work deals specifically with presses used for the manufacture of steel tubes, and for deep drawing plates and sheets. Current designs are discussed on a comparative basis, and thus the book is useful for works managers and engineers, as well as for press designers and engineering students. In the first 109 pages, extrusion presses used for tube manufacture and for deep drawing are described. Then, hydraulic shears and plate bending presses are dealt with, in the next 20 pages. Boiler plate presses are discussed, together with hydraulic riveting presses in 53 pages, and this is followed by a chapter on hydraulic presses as used in shipyards. Presses for sheet metal, as used in vehicle and container manufacture, are dealt with in a separate 34 page chapter and the book concludes with a chapter on the pumps, accumulators, valves and hydraulic circuits employed in the various presses.

CURRENT PATENTS

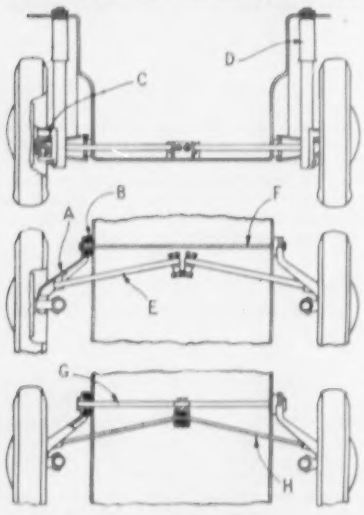
A REVIEW OF RECENT AUTOMOBILE SPECIFICATIONS

Trailing link type I.F.S. system

TO obtain adequate lateral rigidity in a conventional trailing link suspension it is usual to make the links as short as is practicable and to mount them in long bearing sleeves. Larger links are desirable to lessen the chordal height of the arc traversed by the wheel and to reduce angular movement of the link and so permit the use of short torsion rods for suspension. The invention claims to achieve these ends, in a relatively light construction, on systems in which the links are guided in the vertical plane by telescoping shock absorbers.

Link A of pressed sheet metal is pivotally mounted on the frame in an inexpensive rubber-bushed bearing B. At its free end the link is connected by a ball joint to a stirrup member C on the shock absorber D suspended vertically from the frame. The link is braced against lateral forces by torsion rod E, clamped at one end to the link and pivotally anchored to the frame at the other. A torsion bar F connecting the links on each side of the vehicle functions as a stabilizer. The road wheel, of course, is mounted to swivel on member C.

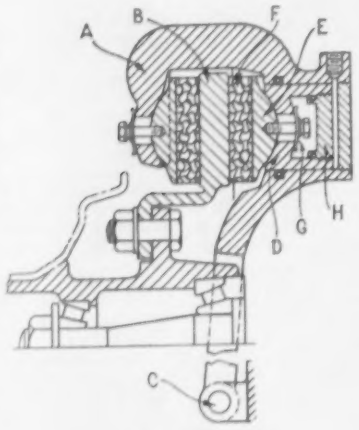
In an alternative construction, suspension is provided by a torsion bar G connecting the links and anchored centrally



No. 728546

to the frame to give independent wheel movement. The links are braced by a torsional stabilizer rod H having a central abutment collar located in a rubber-bushed mounting housed in the central anchor member.

Two further arrangements are described in the specification. In one, helical springs encircling the vertical shock absorbers are used for suspension instead of torsion rods and a centrally anchored torsional stabilizer rod serves to brace the suspension links. The other has a similar stabilizing rod but suspension is by means of a pair of independent torsion rods, one for each wheel link, extending across the vehicle frame at an angle to equalize their lengths. *Patent No.* 728546. *F. Porsche (Germany).*



No. 728709

Single-actuation caliper-type disc brake

WHERE a single hydraulic cylinder is employed to apply a pair of friction pads, one to each side of a brake disc, provision must be made for axial movement of the caliper housing to balance the applied forces. In this instance the housing is pivotally anchored to rock about an axis at right angles to a plane containing the axis of the brake disc. The invention relates to means whereby the friction pads remain parallel to the surfaces of the brake disc so that wear on the pads is substantially uniform.

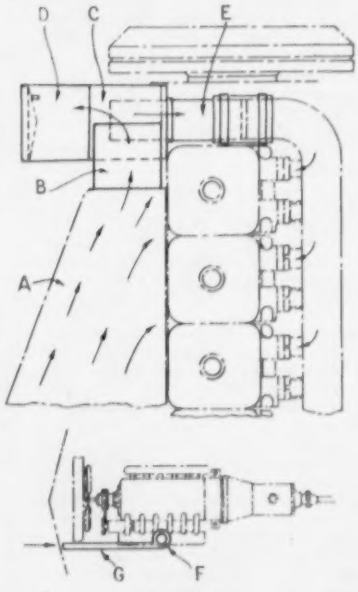
Caliper housing A straddling brake disc B has integral parallel arms for mounting in trunnion bearings C on the swivel head. The arms are extended beyond the axis of the disc to minimize angular movement of the housing as the pads wear. On one side of the housing is formed a hydraulic cylinder, the bore of which is closed by a screwed plug. The piston D working in this cylinder has a part-spherical concavity in its operative face to form a seating for a complementary convexity on the thrust member E to which friction pad F is bonded. Member E is retained in rocking engagement with the piston by means of a bolt loading a domed sheet metal plate G through a spring or a spring washer. The outer end of the piston is closed by a screwed plug H.

On the other side of the brake disc a duplicate thrust member is supported in similar manner in a concave recess in the housing and in axial alignment with the cylinder. Two or more pairs of friction pads may be mounted in the same housing.

In modifications, the second friction unit is supported by a screwed adjuster plug and friction pads may be formed with flats, engaging flats or ribs in the bores, to prevent rotation. The pads then rock only in a plane containing the axis of the disc and their thrust members can be part-cylindrical instead of part-spherical. If a screwed adjuster is fitted to compensate for wear, the complementary thrust member is necessarily part-spherical. *Patent No.* 728709. *Girling Ltd.*

Pressure charging with cleaned air

PARTICULARLY intended for air-cooled diesel engines, this method of supplying combustion air at a steady dynamic pressure through a cyclone type dust extractor can provide a moderate degree of pressure charging. In the case of an air-cooled engine the supply is taken from the delivery of the cooling air blower, but for a water-cooled engine, air is ducted from an inlet arranged in advance of the radiator at a pressure engendered by the forward movement of the vehicle. Oil-bath filters or oiled filter elements, either singly or in conjunction with cyclone extractors should not be used with this system as the air pressure may cause oil, dust, or both to be carried into the engine. For the same reason, the cyclone extractor should be of the self-discharging type, as the pressure may disturb dust falling into a collector chamber. At the pressure delivered by a cooling air blower, efficient operation of a cyclone extractor is assured at all speed ranges.



No. 728711

On a multi-cylinder air-cooled engine a portion of the cooling air delivered by an engine-driven blower to a distribution cowling A is passed tangentially through duct B into the centrifugal chamber C of the dust extractor. The separated dust particles are discharged to atmosphere through slots in the settling chamber D and clean air flows under pressure through outlet pipe E to the engine intake manifold. As shown in the plan view of a water-cooled engine, a cyclone dust extractor F may be arranged vertically below the intake manifold and fed with air through a duct G which is extended forward beyond the coolant radiator. *Patent No.* 728711. *A. Knecht (Germany).*

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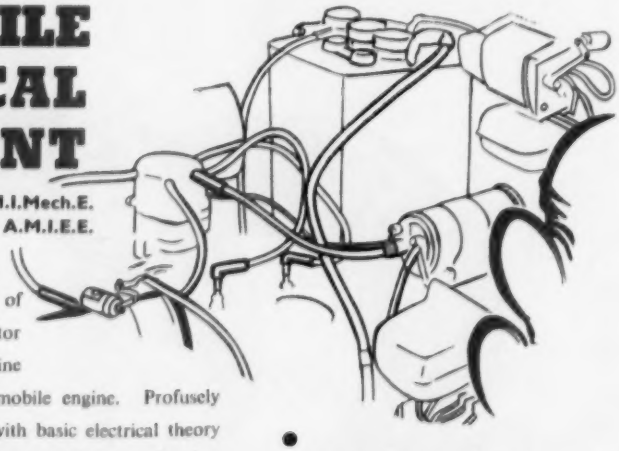

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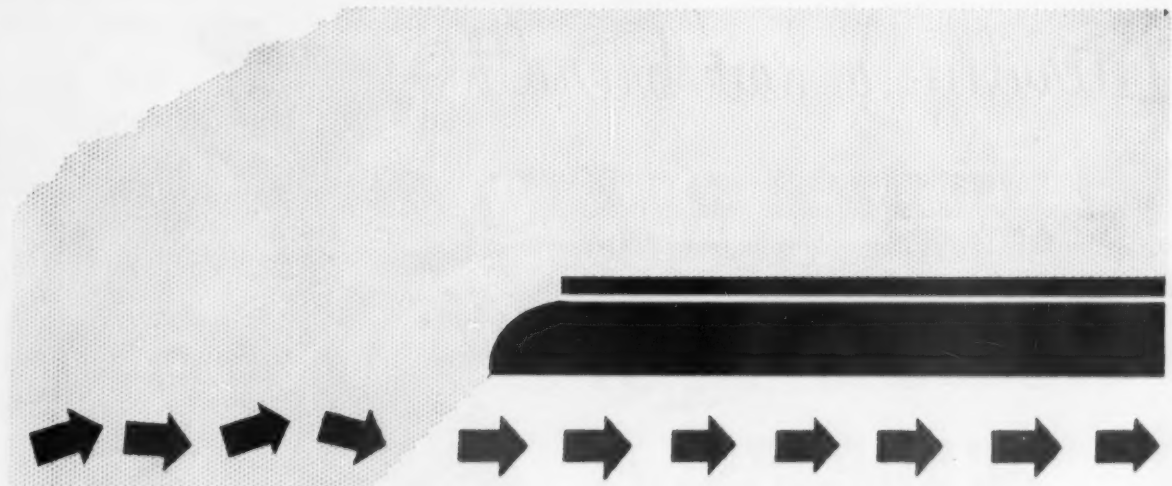

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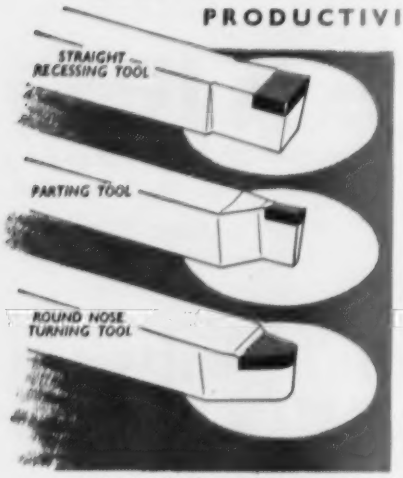

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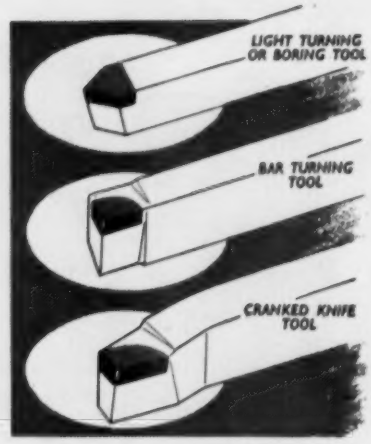

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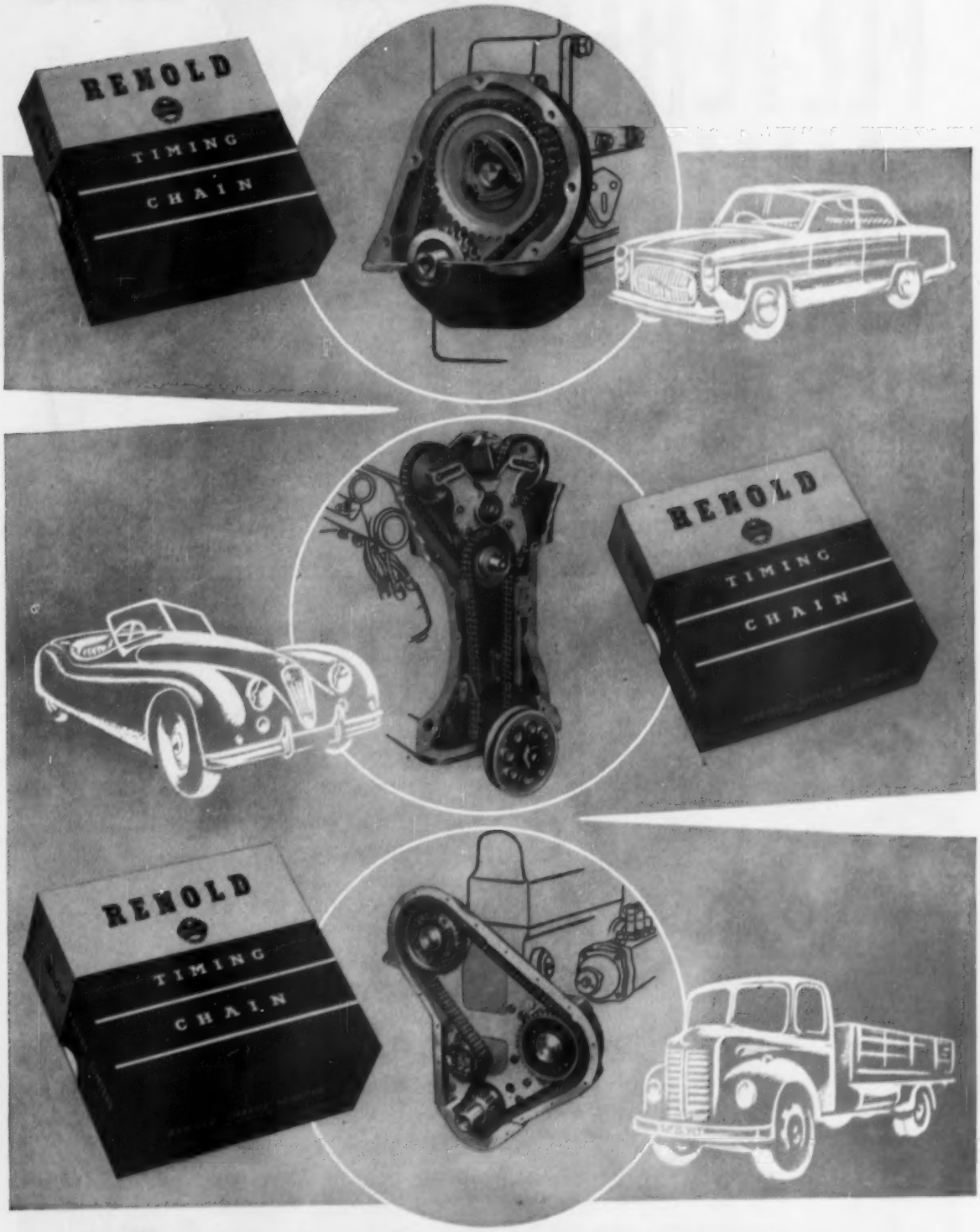

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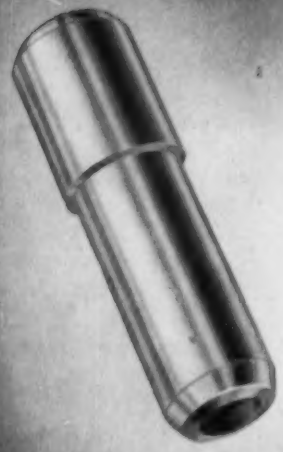

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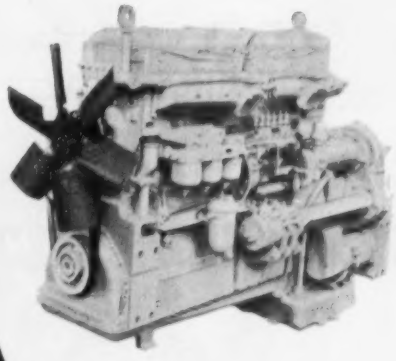

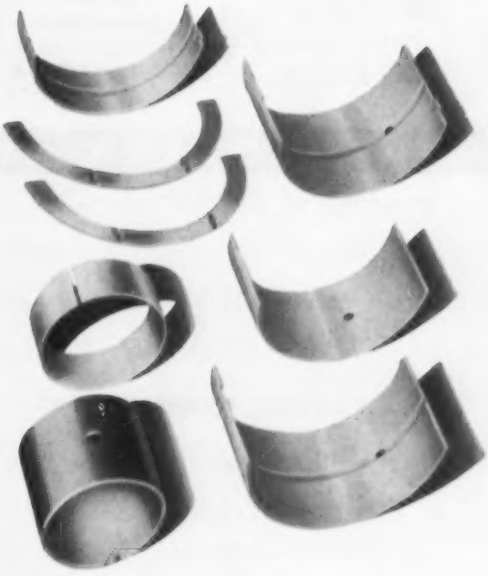

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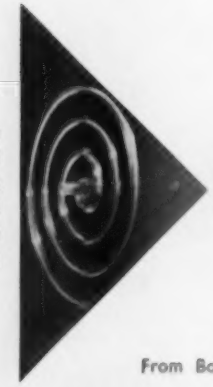

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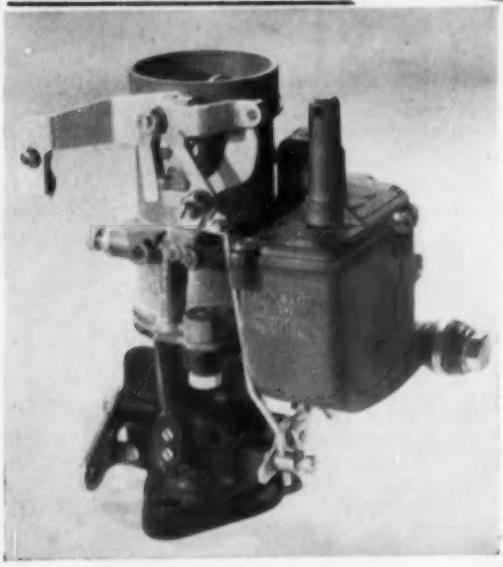

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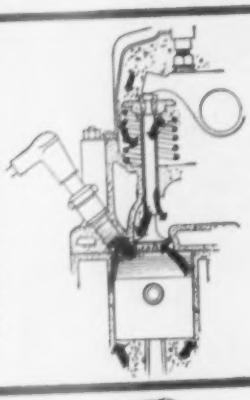

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Austin Magazine, December, 1954

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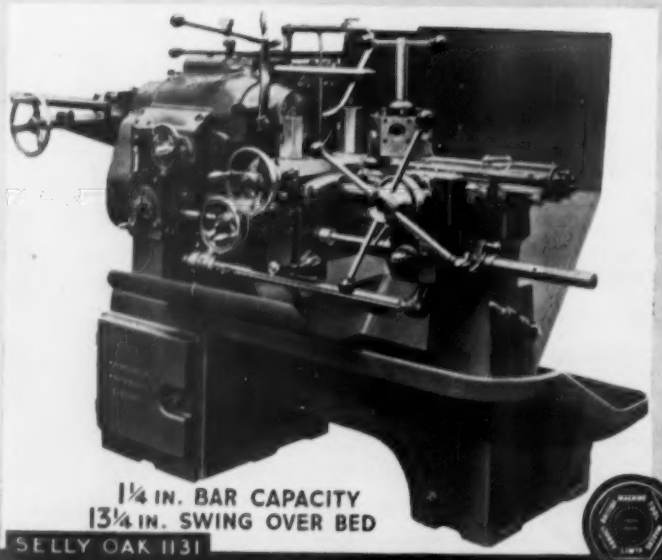

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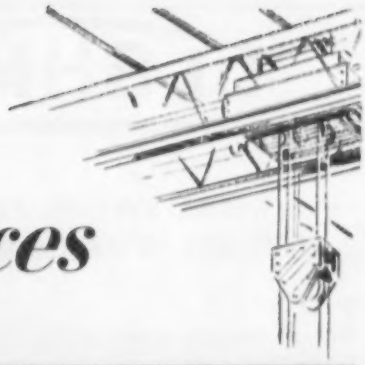

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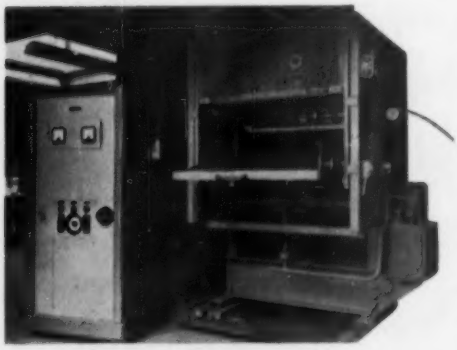

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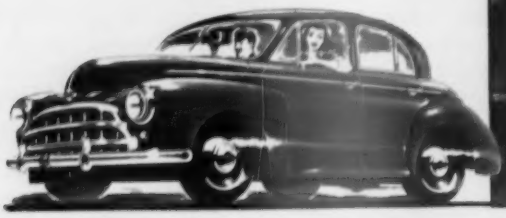

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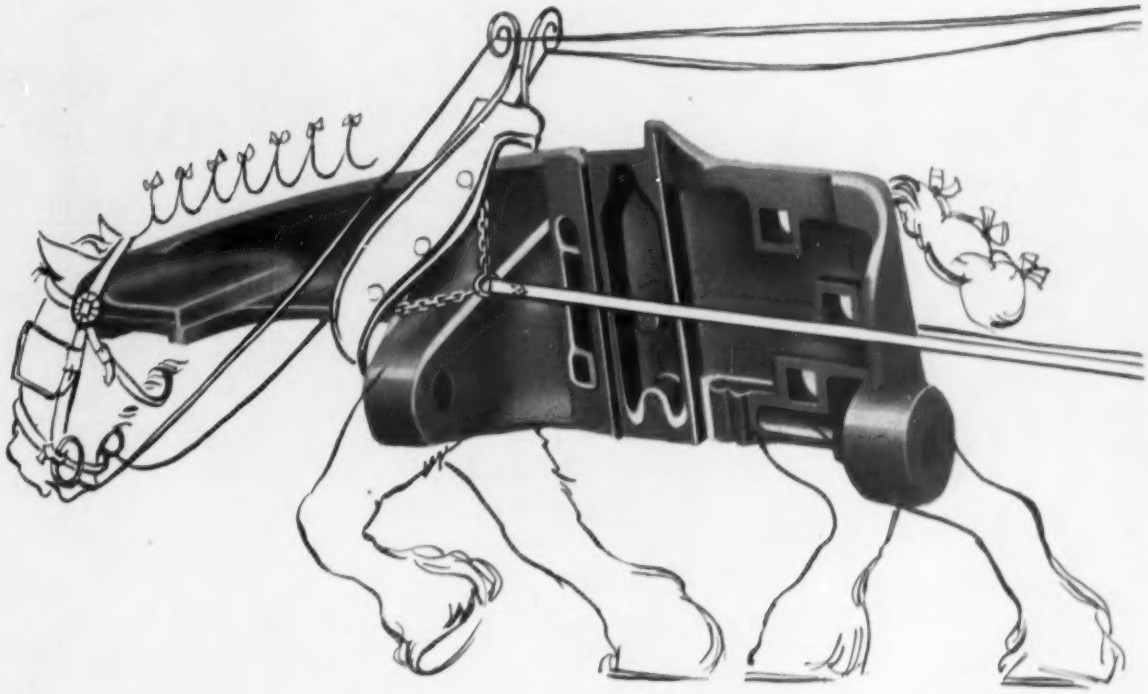

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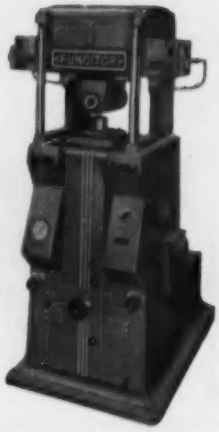

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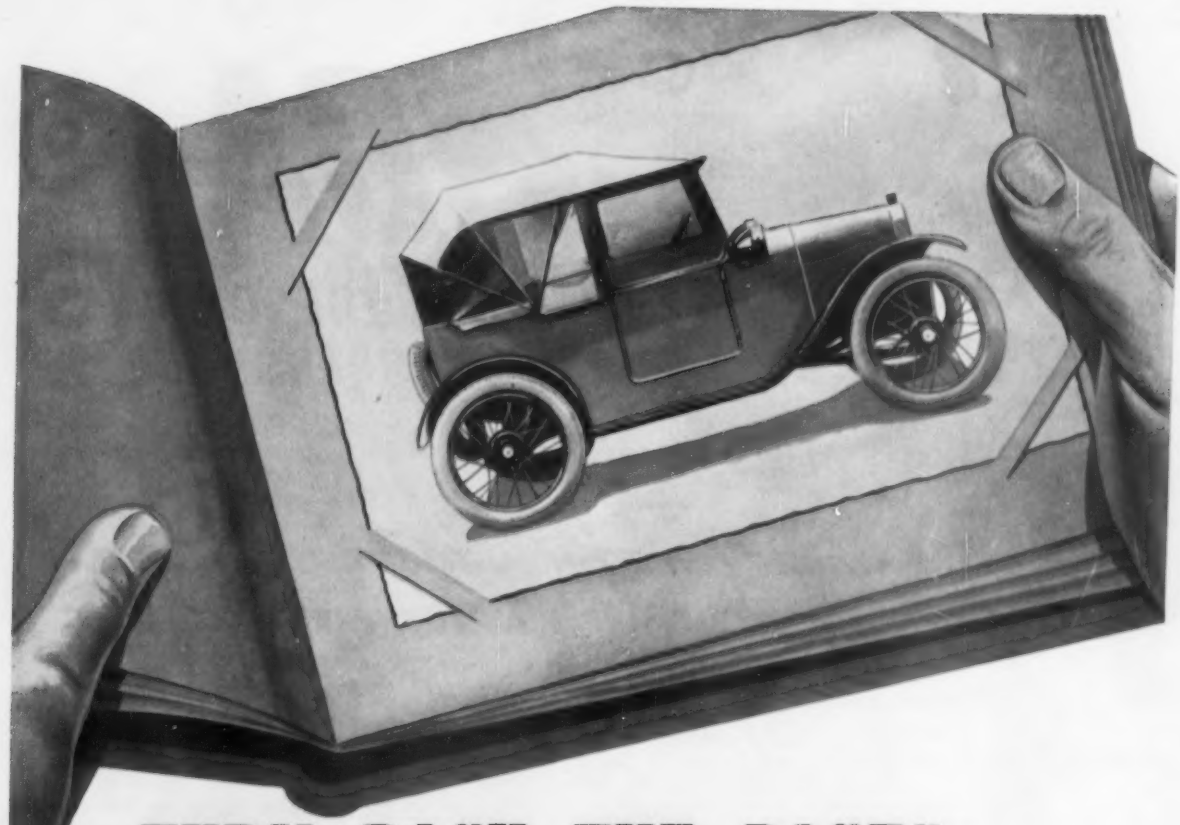

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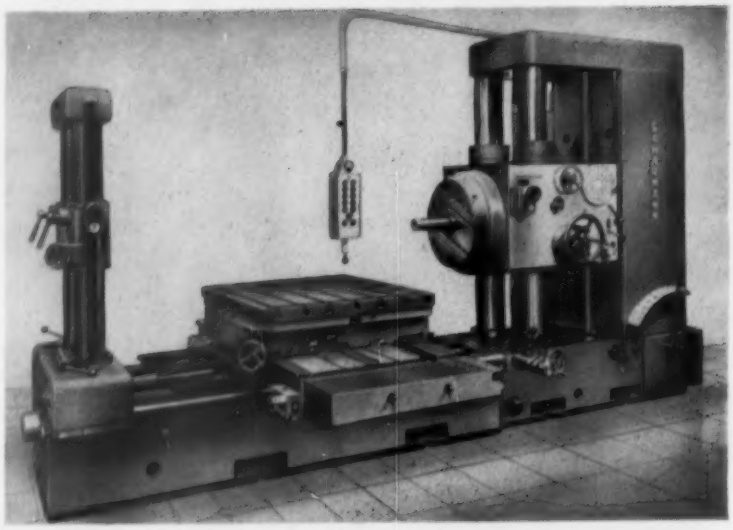

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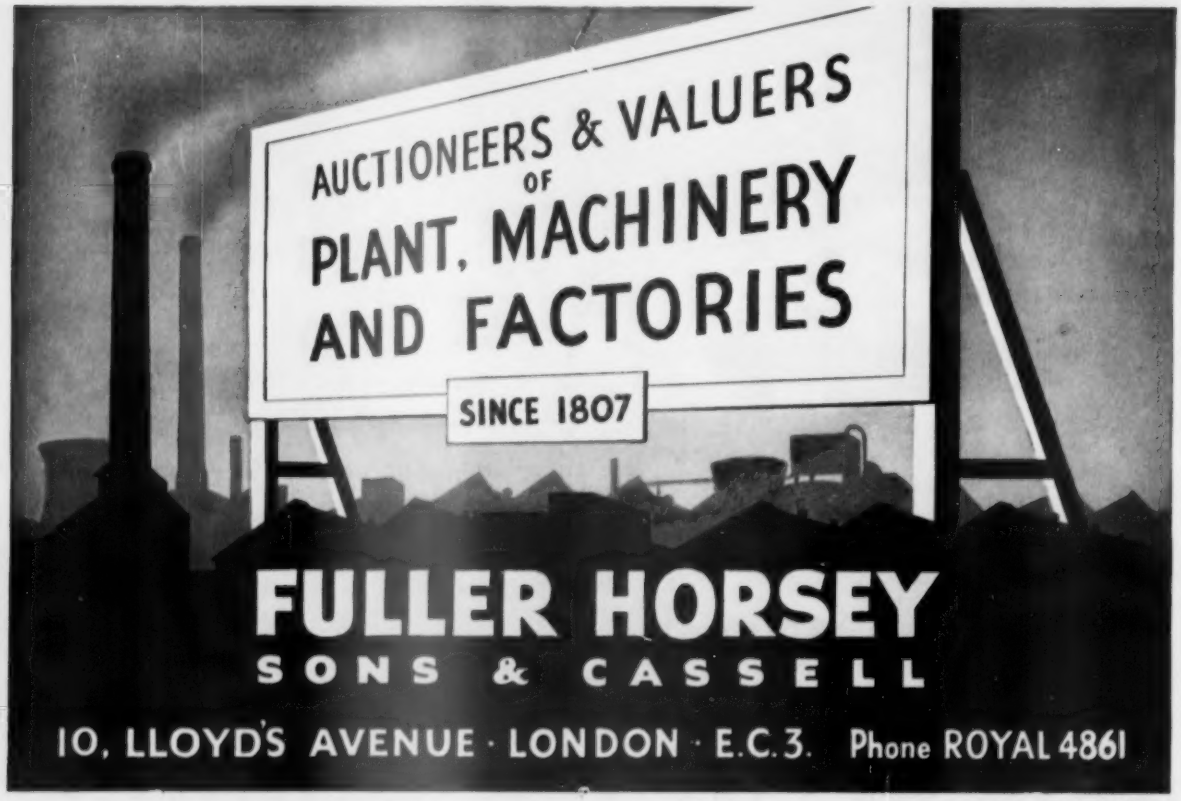

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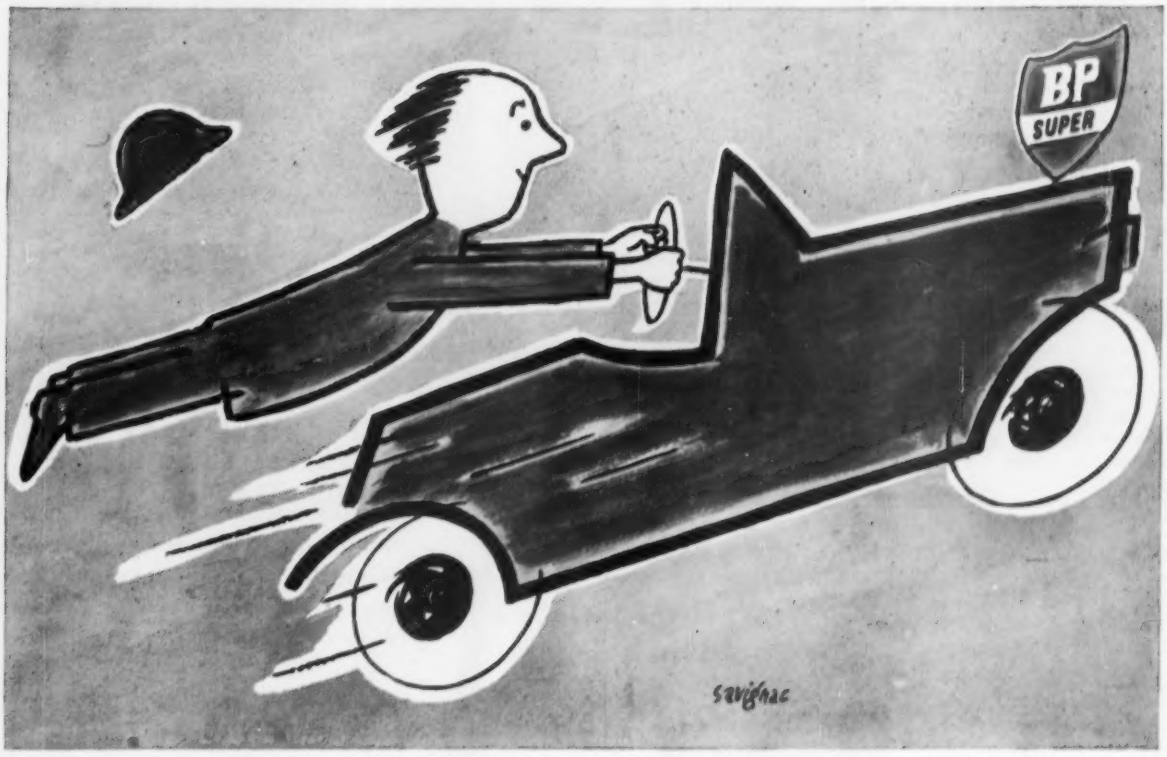

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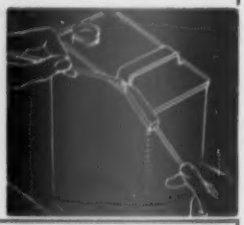

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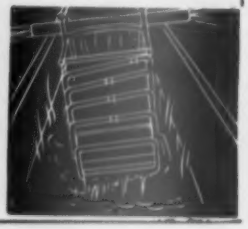

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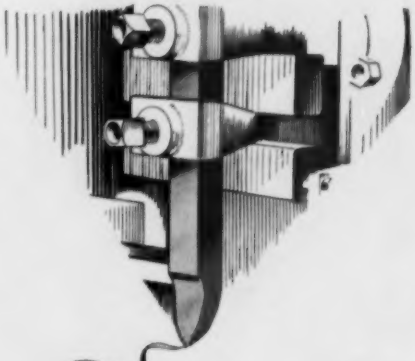

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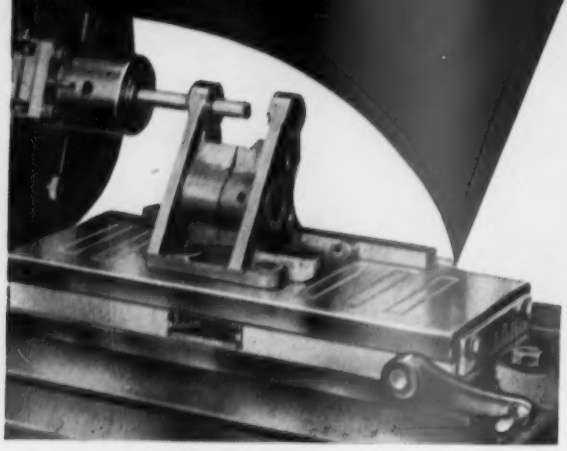

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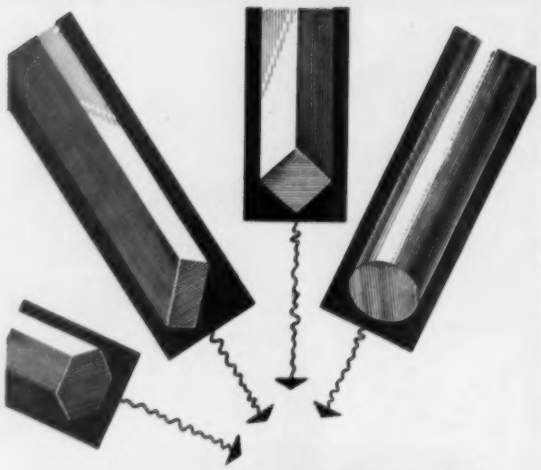

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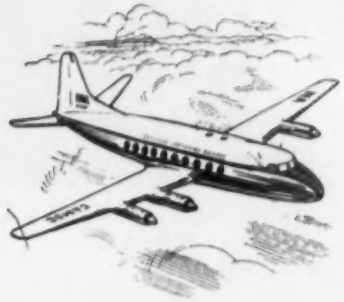

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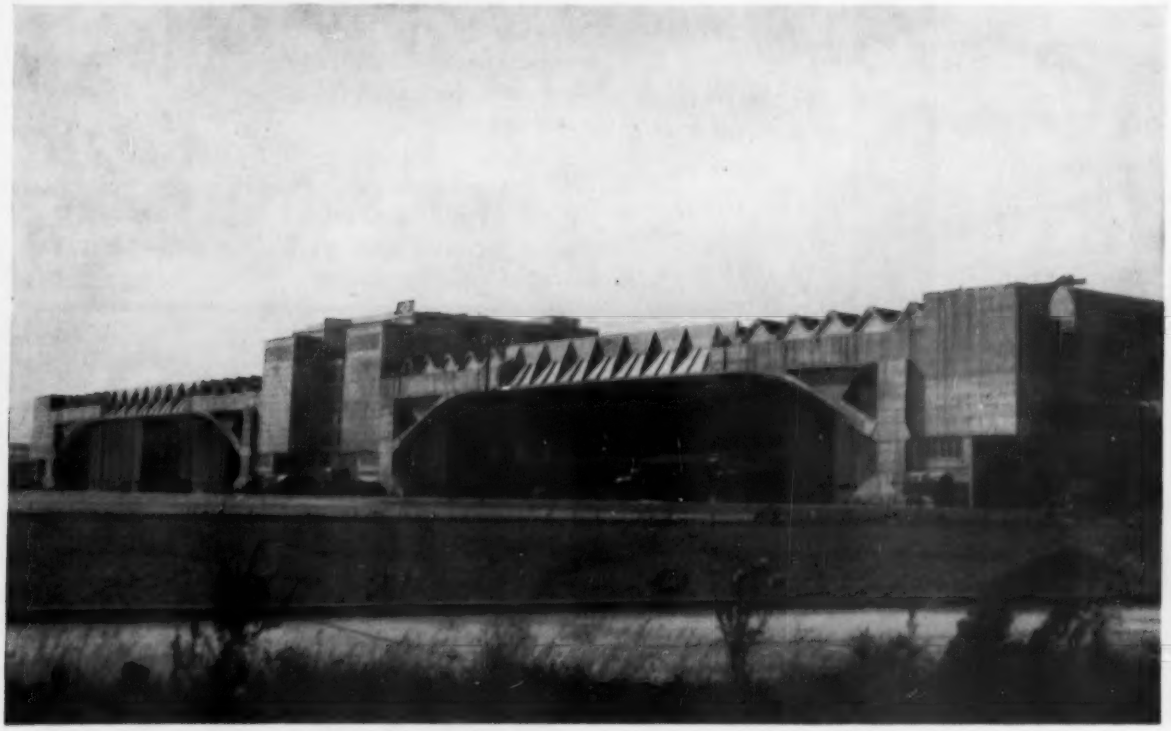

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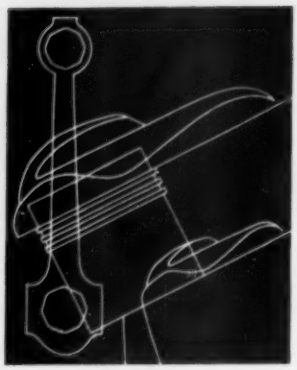

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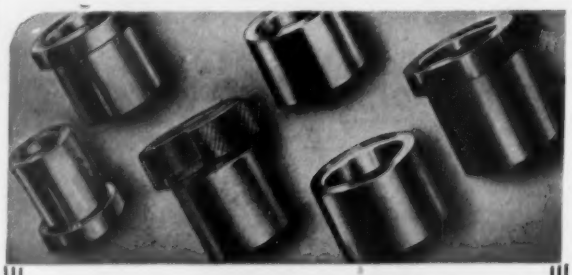

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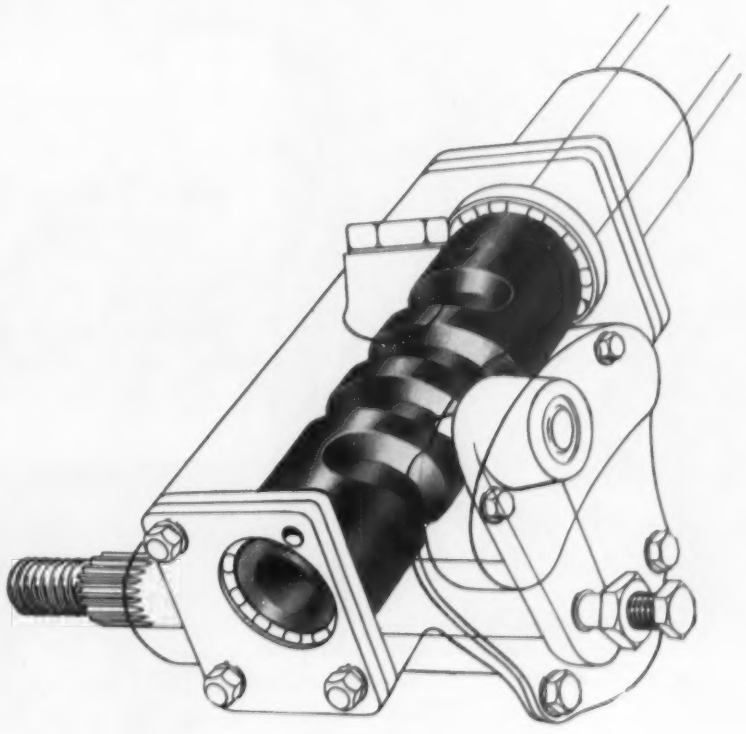

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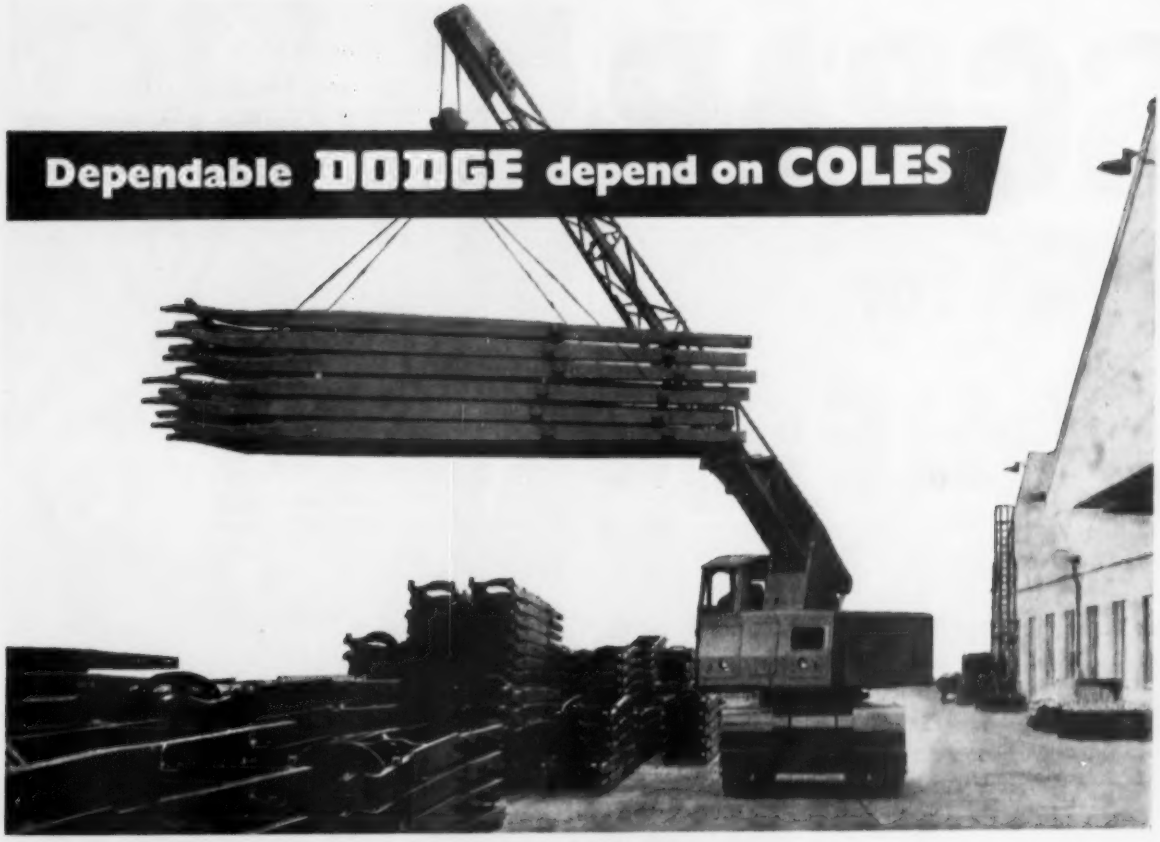

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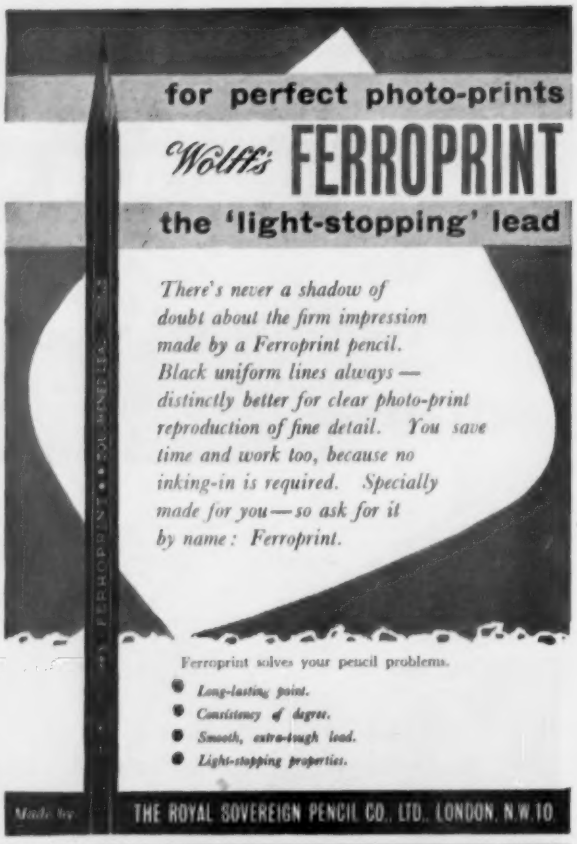
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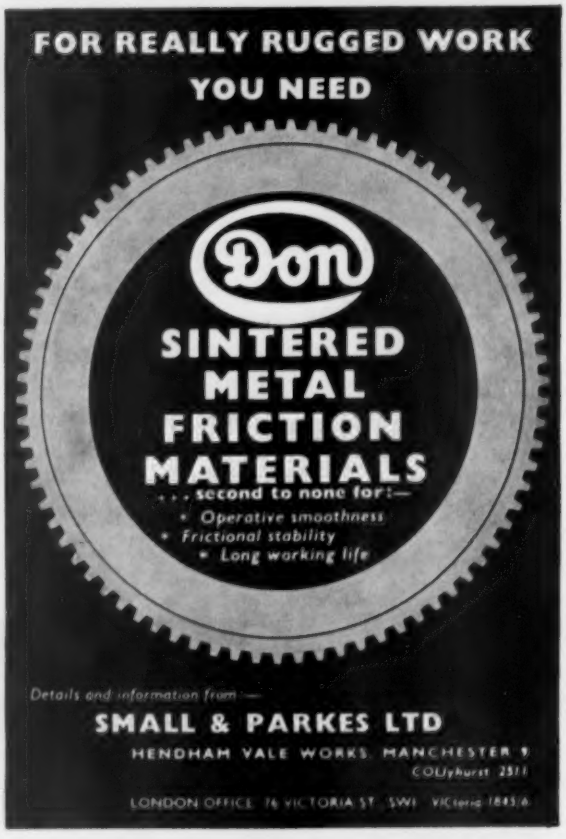
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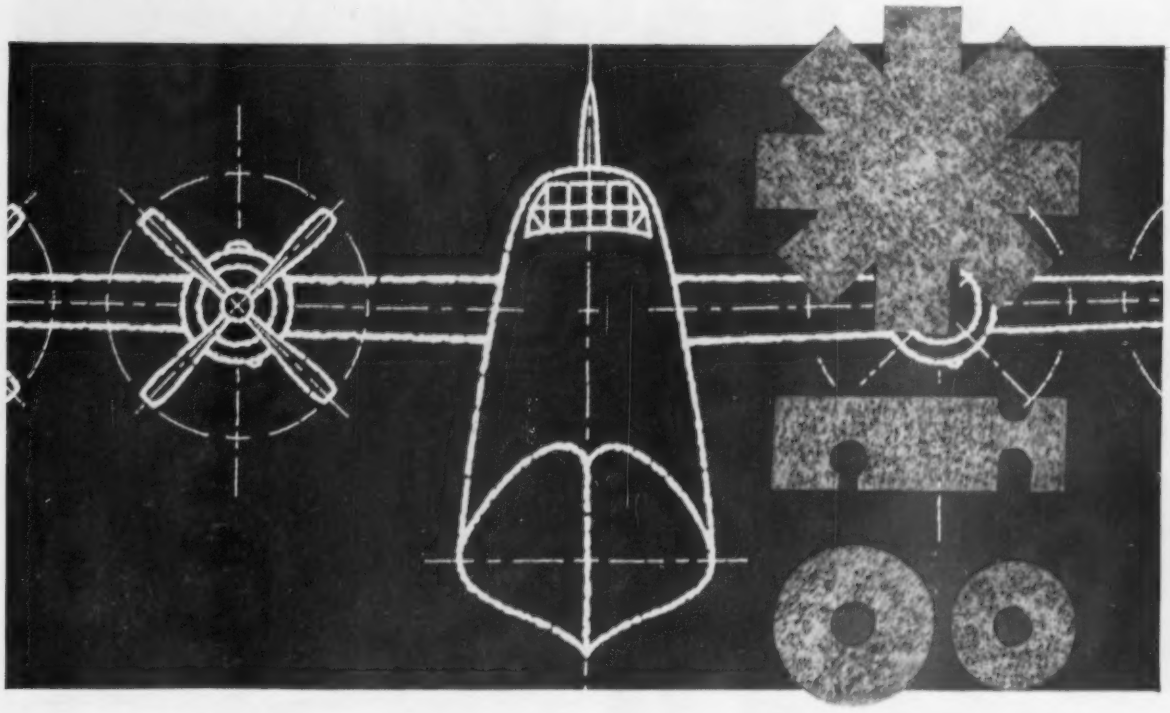

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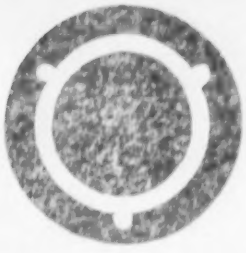

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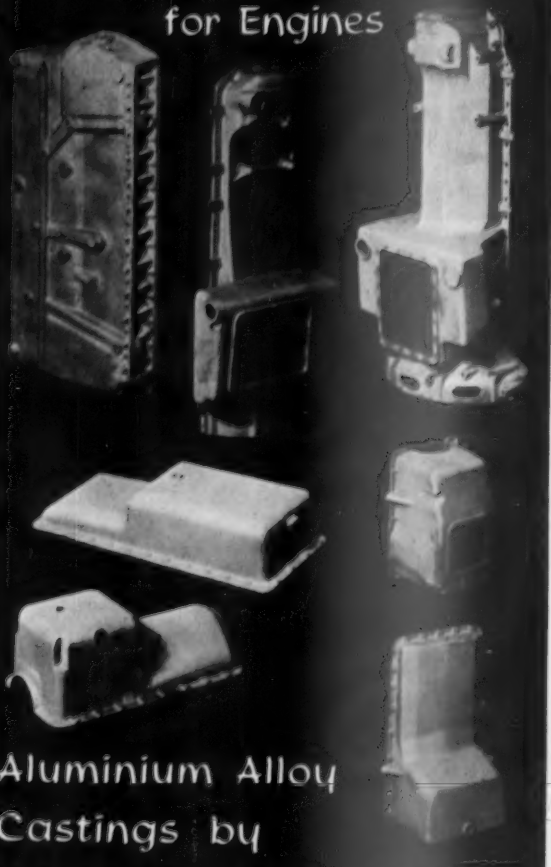

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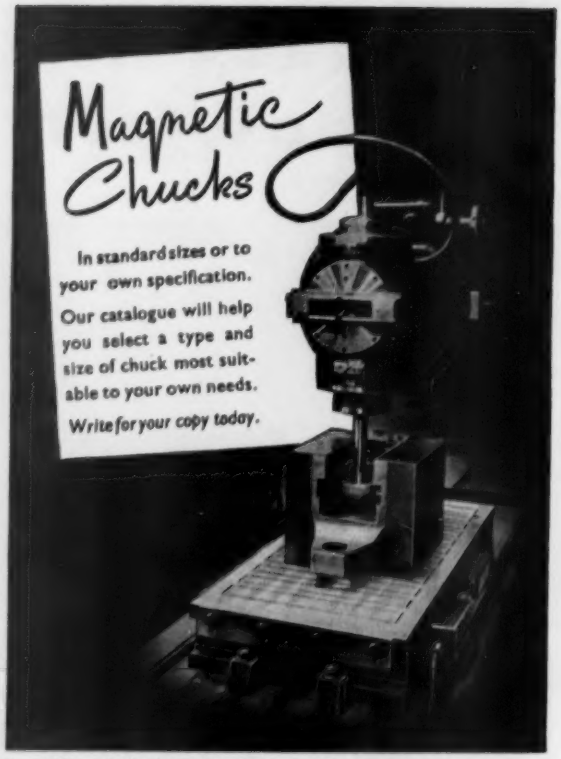

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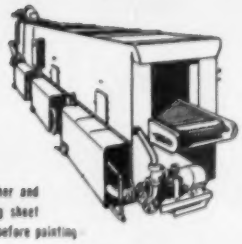

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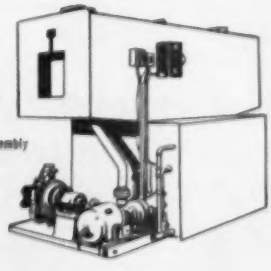

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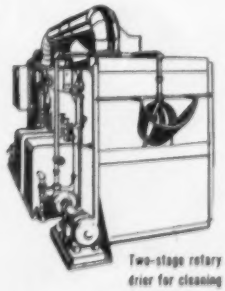

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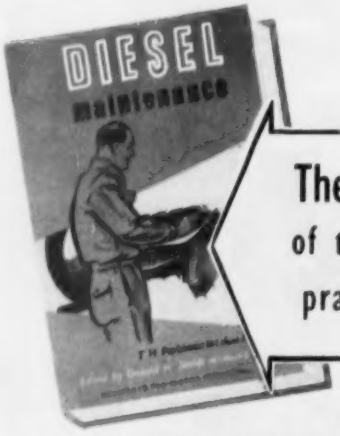

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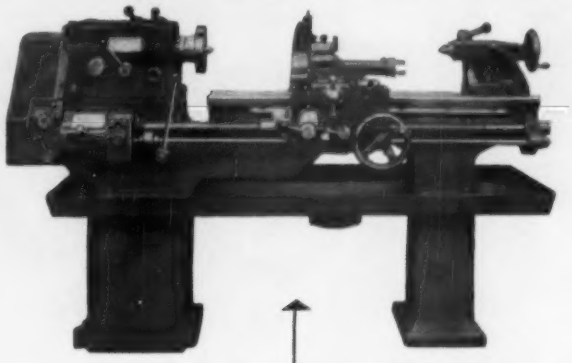

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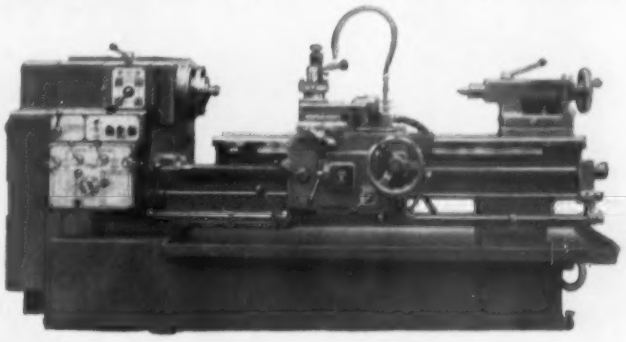

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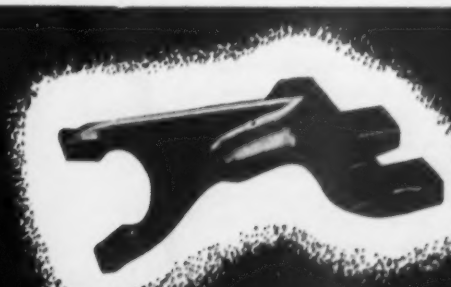

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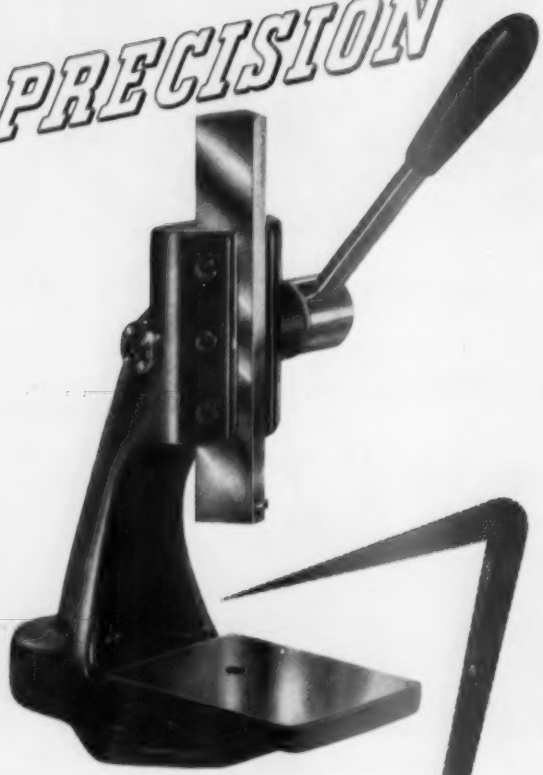

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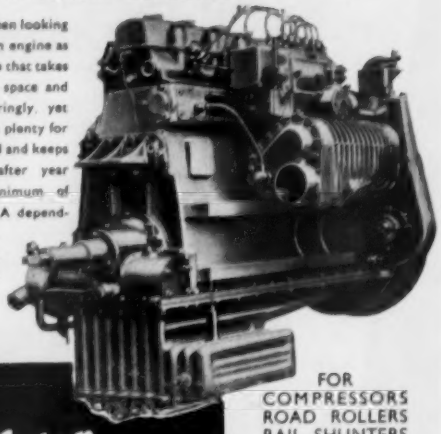

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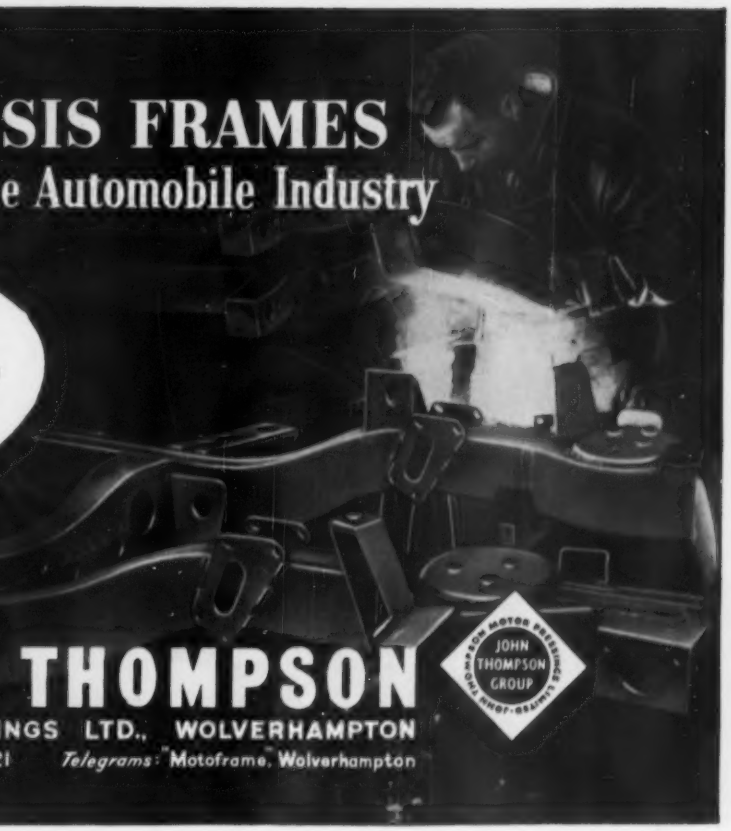

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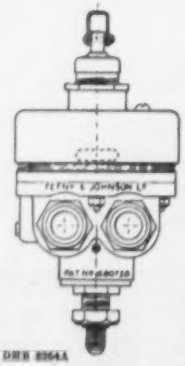

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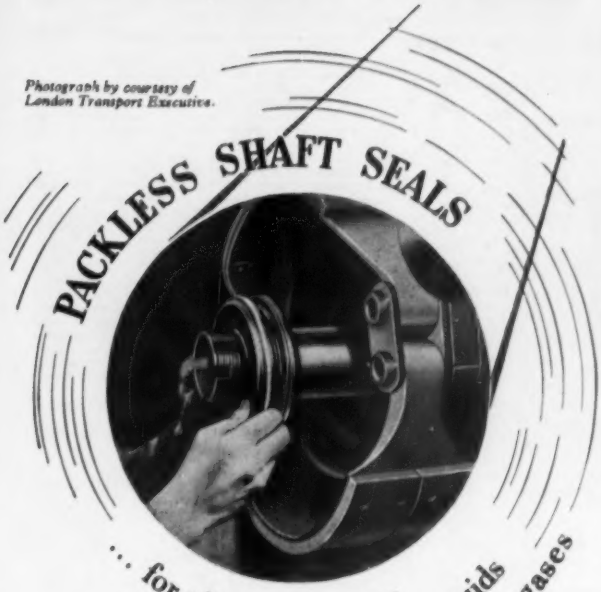

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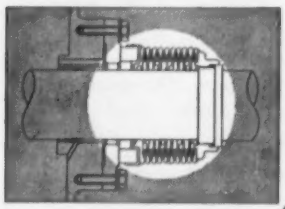

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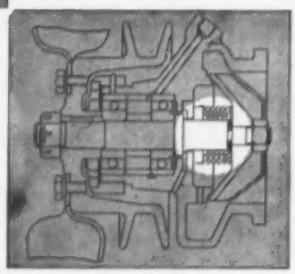

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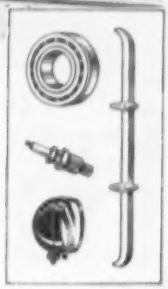

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Application forms and further information from the Civil Service Commission, Scientific Branch, 30, Old Burlington Street, London, W.1, quoting number S 128/56. [5124

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INFORMATION Officer to assist with technical enquiries, translations of foreign literature and abstracts relating to all branches of automobile engineering.

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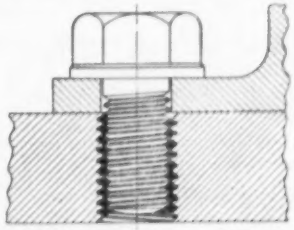

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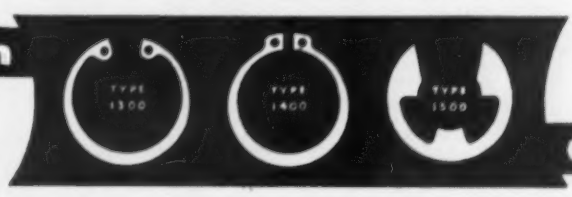

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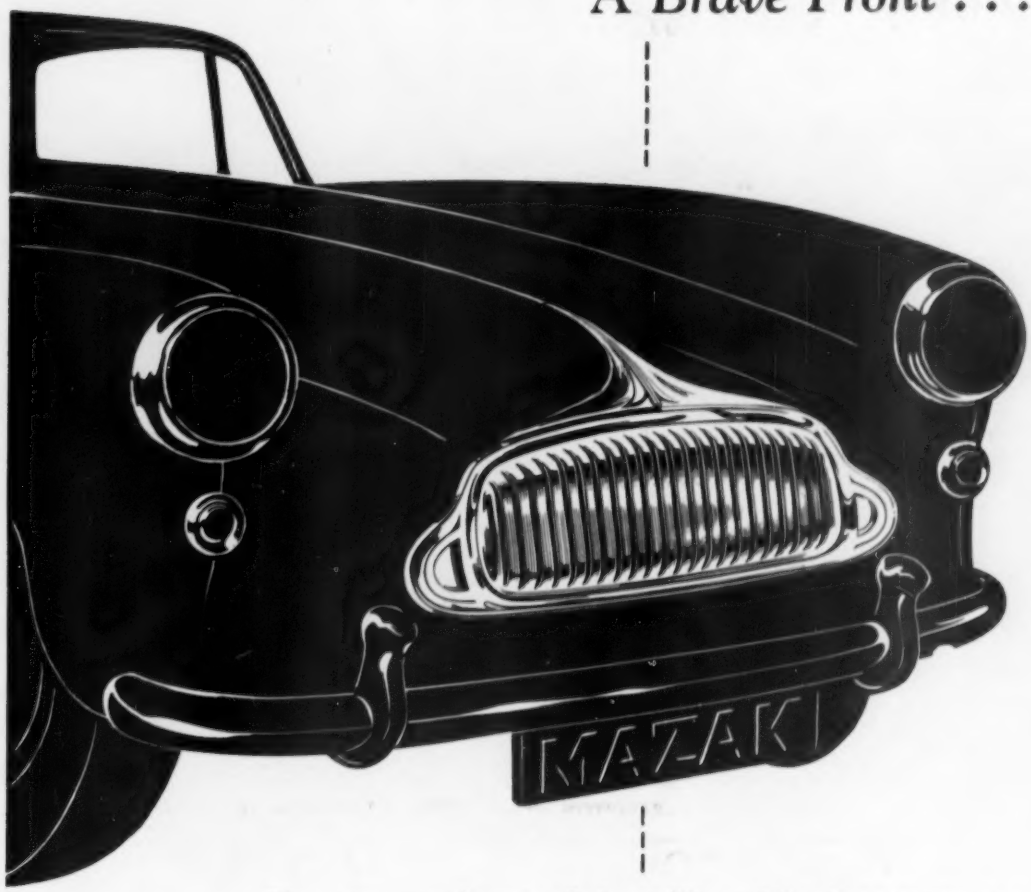

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